

# Bio-Gro, Inc.

Presents:



## CFS - Complete Fertility System

Bio-Gro's Mission Statement:

Our goal is to deliver the necessary **Product Technology** and **Product Support** to help our customers reach the highest yields, quality and profit possible.

These goals will be obtained by fully understanding the customers' needs, developing products to fill those needs, and supplying advanced support and technology.

## Introduction

**“It is estimated that in general, agricultural crops only produce about 25% of their potential yield”**

(Boyer J.S., 1982 in "Plant Productivity and Environment, Science v 218, 443-448)

This yield potential is limited by environmental stresses, many of which can be effected by soil fertility & microbiology and plant nutrition. Some of these stress “factors” can be illustrated by dividing them into three groups:

<b>Physical Stress</b>	<b>Chemical Stress</b>	<b>Biological Stress</b>
Drought	Salinity	Competition
Temperature variations	Soil pH	Allelopathy
Radiation	Pesticides	Diseases
Water variations	Toxins	Pathogenic fungi
Wind	Nutrient fluctuations	Viruses & Insects

Although many of these stress factors cannot be easily controlled, the question is can a further understanding of plant physiology and nutrition lead to fertility programs that could reduce the negative effect on crop yield? Can this information and product technology be utilized and demonstrated in the field to bring higher yields and more consistent crop quality to growers?

Are we saying that by improving our understanding of soil and plant fertility that we will be able to increase yields by 2 to 4 times? No, however, if many crops only produce a fraction of their potential yield, this shows tremendous potential for improvement.

What about focused nutritional approaches to crop quality and marketability? For example, a seed potato grower needs smaller potatoes and lots of them. A fresh market grower needs larger potatoes. [Bio-Gro's CFS – Complete Fertility System](#) would give the information and resources to better control these issues through fertility management, application and timing.

What about using a sound nutrition program to make a crop more resistant against disease and insect pressure? Is it possible to utilize more environmental sound and profitable fertility based programs to suppress disease and insect problems?

These goals are all very realistic. However, it is unlikely that one person with one “magic bullet” will ever accomplish them.

The whole concept of CFS is a TEAM approach to bring together all the people and technology resources into a unified and scientifically credible approach.

There are some very basic and important concepts the [Bio-Gro's CFS](#) establishes and utilizes. It is difficult to give full detail in this introductory document, because

CFS is a combination of all of our information and product technology. This document is a summary of the base approach that Bio-Gro utilizes to implement CFS.

## CFS – The Foundation

The foundation of Bio-Gro's CFS is to approach all crops, fields, programs and customers (both the end users & distributors) can be summarized as follows:

- ✓ Part One – **Gathering Information** – Steps 1 to 5
- ✓ Step Two – **Building a program** – Steps 6 to 10

This will be illustrate in full detail starting on Page 6

Bio-Gro, Inc. is in the business of supplying micronutrients, value-added NPK solutions and value-added bio-fertilizer additives. We will demonstrate that our products are the LAST steps of the program.

### **THIS IS WHAT SEPARATES OUR COMPANY FROM ALL OTHER COMPETITORS!**

There are many fertilizer companies that sell various bio-fertilizers and value-added nutrients, but FEW take a [Complete Fertility Systems](#) approach.

Almost ALL bio-fertilizer companies emphasize PRODUCTS only. Few can even fully understand and communicate basic soil fertility. In the past 4 years, Bio-Gro has been involved with a major US fertilizer distributor and out of hundreds of field agronomists, only a very small number can even fully “read” a soil or plant analysis. Few fully understand the physiology of the crops they grow and fewer still the importance and implications of soil and plant (micro)biology.

This is the MOST important reason that bio-fertilizers have a “snake oil” reputation.

## Bio-Gro's CFS, a 3-Dimensional Approach

An important fact to help understand in a **Complete Fertility System** is to first understand how many professionals currently view agriculture.

The general approach to agricultural production is basically **chemically** orientated. This is especially so in “modern” agricultural countries such as the USA, Canada, Australia and many European countries. For example, when there is a disease or insect attack, no one looks into the **CAUSE** of the problem, but always address the **SYMPTOM** of the problem by putting on a chemical (or even a biochemical) and attempting to eradicate the problem. This simple approach also includes **MANAGEMENT** or the **physical** side of a 2-Dimensional System

Notwithstanding, this approach has been very successful, but there is a growing awareness of the cost to the environment and even more importantly, in many areas the cost of food production is now so low, many growers struggle financially. **THIS IS OUR OPPORTUNITY!**

Summarized, the current agricultural system is 2-Dimensional:

<b>Physical Management</b>	<b>Chemical Management</b>
❖ Irrigation	❖ Dry Fertilizer
❖ Tilling	❖ Liquid Fertilizer
❖ Weather	❖ Trace Minerals
❖ Drainage	❖ Fungicides
❖ Soil Type	❖ Insecticides
❖ Nutrient Placement	❖ Herbicides
❖ Timing	❖ Fumigation

Furthermore, one should add that few fully understand and can make all the parts of this 2-Dimensional system work together, especially on the fertilizer side.

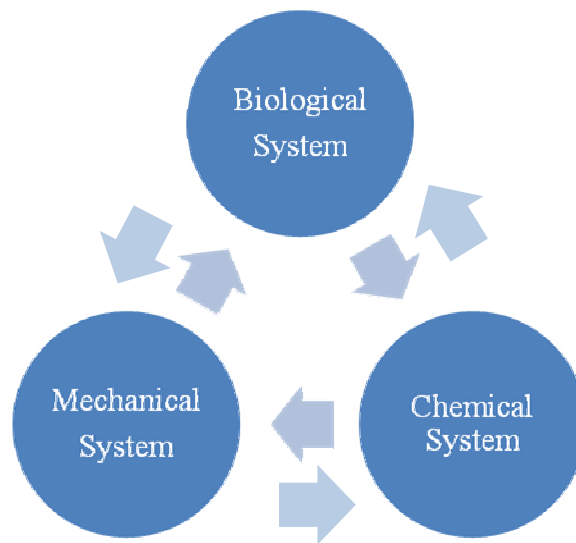
This simple, two dimensional system would work fine, however, there is a third and more complex dimension that comes into the picture; the **biological** system.

Unfortunately, for most involved in agricultural production, they only experience the “*negative*” side of the **biological** system. Ironically, most of this negative biology (disease & insects) is caused by the imbalance of the **chemical** system. Soils have been depleted of minerals and only water-soluble NPK fertilizers are emphasized. Few farming systems fully address the importance of **BALANCING** cations like calcium, magnesium and potassium. Fewer still apply adequate amounts of boron, zinc, iron, manganese and copper. Not to mention the importance of lesser-known elements such as cobalt and molybdenum.

As these negative biological functions advance, **chemical** systems are used in an attempt to control the environment. Again, the simple 2-Dimensional approach

leads to further problems such as: disease resistance, chemical buildup and severe nutrient imbalances. Furthermore, these attempts to suppress the pathogenic, or negative, biological functions, can result in increased damage (imbalance) to the natural "*positive*" biological systems.

**Important Fact:** Notice that an imbalanced biological system is the result of an imbalanced and poorly administered chemical system. Therefore, attempts to add a biological "snake oil" are often unsuccessful and always inconsistent on a large scale. Therefore, it is SO important to address ALL of the parts of CFS; **Physical, Chemical & Biological**



Notice that the arrows point in both directions; each method of applying CFS is interdependent. A proper understanding of ALL the aspects of the 3-Dimensional is important. In the following pages we hope to illustrate how this will all be tied together into a Complete Fertility System.

## Building a CFS Program

Bio-Gro's Complete Fertility System can be divided into two sections;

### Step One – Present System – Information Gathering

- 1) Financial analysis
- 2) Yield analysis
- 3) Quality analysis
- 4) Information Source analysis
- 5) Historical analysis

### Step Two – Future System – Building a Program

- 6) Amendment requirements
- 7) Macronutrient Recommendations
- 8) Micronutrient Planning
- 9) Soil Microbiology applications
- 10) Plant Stimulant developments

**Step One – Financial Analysis;** this doesn't mean an audit, but a general outline of production costs. The information will help us focus on the areas of production where the greatest improvement can be made.

For example, if a producer is spending \$200/acre on fertilizer and \$400/acre on disease suppression, we would further breakdown the fungicide inputs into cost per disease. At this point, we would research the disease problem, suggest alternatives of controls and likely suggest changes in the fertilizer application to increase the natural ability of the plant to suppress disease.

**Step Two – Yield Potential:** although this may be difficult to accurately predict, knowing the potential of yield is important in developing a fertility program.

For example, we know in Washington State that fields that have never been planted in potatoes often yield 40 tons and more per acre! Average yields in these areas are 35 tons & less. This gives us a base of information to work with. First, knowing that it is possible in the field is important. Secondly, we can now begin to assess the differences between "virgin" and "farmed" soils to give us a guideline on fertility development.

**Step Three – Quality Requirements:** surprisingly very little emphasis on outlining the requirements of produce/crop quality in relation to fertility is done today. Some larger seed companies are developing seeds that tend to produce certain desirable qualities, but this is still not enough to overcome potential differences in soils, temperatures, growing practices and other uncontrollable situations.

Our Technical Services include identifying the most desirable characteristics of crop quality and end user requirements. Often we find that this is more valuable to our customers than increasing yield. After we have identified the most important qualities, we will study growth patterns, soil conditions and plant physiology to attempt accurate manipulations or control of quality production.

For example, we can utilize various rooting agents and root colonizing microbiology to cause set manipulation on potatoes. If a larger set is desirable, we can increase the number of tubers set early. If larger tubers are desirable, we utilize agents that put on an early but even set and then monitor plant stresses and utilize foliar applications to suppress further set. This example pertains to potato production, but we have many other examples in feed quality, food quality, seed quality and produce storability to demonstrate the effect of fertility and plant fertility aids to overall quality.

**Step Four – Soil Characteristics:** no fertility system is possible without examining not only soil tests, but also the accuracy of these tests. Basic soil tests will include sufficient information on levels of nutrients, pH, organic matter and other important characteristics, but the first question we will ask is how accurate are these numbers? Does the lab performing the analysis do the most accurate extraction method for the particular soil/crop?

For example, we found that many labs calculate CEC by adding values of Ca, Mg, K & Na. However, if the lab utilized calcium extraction methods based on clay soils, we found that calcareous soils would show CEC's of up to 30 in pure sand! This is of course impossible and the example is severe, but even in closer calculations it is critical to know true CEC and levels/availability of calcium

Our technical services will include checking the accuracy of soil analysis values against other laboratories before recommending large scale testing. This information is critical in planning soil fertility programs because it will give us more than insight into levels of nutrients required, but also forms and placement of nutrients required. Forms & placement are often more important than levels applied!

**Step Five – Historical Information:** ironically few fertility experts spend a lot of time gathering historical production information. Our experience has shown that this information is critical in developing the most efficient system of production in the shortest period. Therefore, we gather as much information as possible on past practices, programs, successes, failures, observations and conditions as possible. This is the final step in gathering information.

For example, we found that barley grown in Alberta was bred to grow shorter (semi-dwarf varieties) because with the increase of nitrogen application it tended to lodge more. Generally, agriculture utilized plant breeding to produce higher yields with more nitrogen that worked to a certain extent. The downside we discovered was the increase in weed control costs. A large-scale experiment was conducted in which we planted older varieties, but used a balanced approach to nitrogen, potassium and other element fertility. We were able to produce similar yields, higher feed value per bushel and surprisingly wild oats did not grow in the old varieties as it did in the newer varieties without weed control. Our conclusion was that although plant-breeding programs produced a desirable response in yield, feed quality and plant allelopathy was suppressed. This is a complex example, but an interesting demonstration of production history.

**Step Six – Soil Amendment Requirements:** in most cases, this is likely the first step in improving yield and quality over standard fertility practices. Soil amendments are calculated from pH, organic matter, CEC and possibly other necessary factors

such as E.C., soluble salts, chloride and/or bicarbonate. Some factors of soil quality that cannot be overlooked, soil amendments are the most critical. Our soil amendment recommendations are presented as follows;

- a) The level of each amendment recommended (lime, gypsum, dolomite, sulfur, compost, etc.).
- b) The most economical form – This may include information of sources and forms of amendments; particle size, source and availability.
- c) Application Planning – Based on availability, production requirements, input costs and important consideration such as land ownership (rent or own). This also includes evaluations of need for variable rate applications and testing.

For example, if a soil is compact due to low levels of calcium, it doesn't really matter how well the NPK fertility program is implemented, or how well biologicals are used; the result is still always the same. The soil will still be more susceptible to disease, poor drainage, poor water utilization and increasing accumulation of microbial toxins and disease causing organisms. In many cases, soil amendments are likely the most important change required.

**Step Seven – Macronutrient Planning:** nitrogen, potassium, phosphorus and secondary nutrients such as sulfur, calcium and magnesium are important elements for crop production. However, in many cases nitrogen is likely the most over used element and potassium the most overlooked. This approach is supported by the fact that aside from C, O & H, nitrogen and potassium are often 70% to 85% of the elements that make up plants. This doesn't diminish the importance of the other elements, but it does illustrate the importance of the timing and uptake mechanisms of N & K.

Macronutrient planning is considered as "basic" fertility. The part that Bio-Gro will play is not one of supplying these major elements, but rather one of recommending the most efficient form, placement and timing. A plan will be presented based on the necessary information gathered. We can further illustrate this step by the following nutrient examples;

**Nitrogen – N** is important for "stem" or "foliage" growth for most plants. Under application is sure to result in the largest decrease in yield & quality potential. However, all too often it is used (or becomes available) too late in the growing season with negative impact on yield and quality. Our focus will be on form and timing with emphasis on balance with other elements such as calcium, boron, potassium, sulfur and even little known elements such as molybdenum.

For example, in the carrot industry mechanical harvesting requires a healthy carrot top. We found that applications of late season N were utilized to benefit late season top integrity. However, this was at the expense of maturity (color and taste) because of the effect of nitrogen. We solved this by putting on the required N slightly earlier in the season and foliar feeding slow release N + PGR precursors in small quantities late in the season. This provided enough N for protein integrity and yet low enough that the plant could naturally mature.

**Potassium – K** availability is directly related to the level of K on the clay (should be 5% to 9% of CEC) and just as important the type of clay. Our publication on soil colloids and CEC illustrates the importance of understanding these fundamental mechanisms. It must also be pointed out that, to the demise of crop production, rarely does clay type become a factor in potassium application methods, timing and rates.

For example, in a low CEC, low pH growing area we found that the clay type (although present in only small amounts) was less capable of holding K at a low pH than at neutral. This problem was further complicated by potato scab pressure when neutralizing soil pH with adequate lime. Historical applications were 100% of required K in the fall. By understanding the basic principles of soil chemistry, we moved applications up to 40-50% in spring and balance through the water at optimum plant uptake period.

**Phosphorus – P** availability is of course strongly influenced by soil pH. We have found that P is the easiest element to improve on by placement and form. Commercial applications of phosphate fertilizers have a very low efficiency (less than 30%) in some soils. Furthermore, P is greatly affected by soil and plant root microbiology, as experience illustrates even the form of P can have a negative or positive affect.

For example, in a calcareous soil large applications of commercial P are required to get enough P to grow the crop. To further complicate this, the form of P routinely used is liquid polyphosphate solutions. We have demonstrated that polyphosphate P suppressed the capability of plants to support mycorrhiza (VAM). This further aggravated the poor P efficiency. We found that by placing low amounts of ortho-P (half) and supporting this by small amounts of direct seed placed P + VAM support, gave us higher yields and greater P availability.

**Calcium – Ca** is one of the most overlooked elements in relation to disease resistance (costly control) and produce quality (shipping, storing & replanting). However, calcium applications must be done with a thorough understanding of soil chemistry and plant physiology. Although calcium should be supplied as part of the soil amendments, in some cases this is either not enough or impractical. At this point, it becomes necessary to make "strategic" calcium applications.

This approach is never one single "magic-calcium" bullet, but a complete systems approach that takes into consideration form of calcium, timing of application, form of chelating agents and application of compounds which increase the ability of plants to take up soil calcium. The latter method is likely one of the most overlooked by sensible solutions to calcium deficiency providing that there is some base calcium present in the soil.

For example, many fruit producers are aware of the calcium/fruit quality issue. Yet, in spite of numerous foliar applications of calcium chloride late in the season, fruit quality problems still exist. The solution is the understanding that the present year's fruit calcium was already determined in the past season! In potato production, the largest increases in calcium efficiency are demonstrated by seed piece calcium contents, not in season calcium applications!

**Magnesium – Mg** is often overlooked in grass and high sugar (starch) crops such as potatoes. Furthermore, magnesium availability is determined by % of the CEC. This recommended percentage range (10% - 15%) was established for corn grown in the State of Missouri, USA. We have made progress by utilizing a chlorophyll meter to demonstrate the need for Mg, even in high Mg soils. Furthermore, it is not recognized that less than 20% of a plant's magnesium is located in the chlorophyll itself, illustrating the importance of magnesium in other plant functions. One of these appears to be in the translocation of starch to tubers in potatoes.

For example, in nutrient timing work we noticed that the peak of magnesium uptake is higher in a later point of plant development (potatoes) than most other elements. Furthermore, we found that in soils with overall low levels of Mg (in spite of % CEC) potatoes could be kept producing 2-3 weeks longer with water run applications of magnesium.

**Sulfur – S** is often missed with its timing with N applications. Nitrogen efficiency can be increased by maintain adequate S levels or applying N & S together. This is likely due to the requirement of S in protein development. Sulfur applications, like calcium, also illustrate the need for monitoring of particle size. In high pH soils, sulfur is used as an amendment to reduce pH. However, this use has mixed results because growers are unaware of the need for small particle size and sulfur efficiency. This is part of the Bio-Gro, Inc. [Complete Fertility System](#).

For example, using variable rate application technology, potato fields are balanced by adding a pre-calculated amount of sulfur (in the right form) and reducing the pH. In spite of the hundreds of thousands spent yearly on variable rate agriculture, few do this simple program. However, the results were so convincing that the grower will budget up to \$100/acre on this soil amendment, EVEN on a rented field. The credibility gained by this successful program has lead to many other product sales and improvements.

**Step Eight – Micronutrient Planning:** although micronutrients play a small role in plants as far as the level of requirement is concerned, they can affect yield and quality more than decreasing availability of nitrogen or potassium. It is generally accepted that complete soil tests are important for micronutrients. However, we take this a little further by calculating the effect of pH on micronutrient availability and the optimum uptake window of the crop grown to determine the best timing and application.

For example, spring or fall applications of zinc, manganese or copper can be illustrated as ineffective in calcareous (high pH) soils by taking another soil test at the point the crop puts on most of its foliage development (this is 25-40 dae for potatoes). The levels of soil minerals are often as low as fall or spring tests indicate. We have found it more effective to side dress small quantities (10-15% of recommended) followed by a water run (20% of recommended) and well spaced foliar applications during foliage development.

Another important issue of micronutrient planning in relation to plant growth is to recognize that many currently utilized methods of plant analysis are incapable of accurately predicting micronutrient deficiency. In most cases, these tests are performed too late in the season or performed on the wrong part of the plant

(petiole). Our approach is to supply enough to soil applications, plant foliars and monitor the requirement of important micronutrients such as Fe, Mn, Zn and Cu by testing foliar applications with a chlorophyll meter.

**Step Nine – Biological Planning:** only **after** the proper implementation of amendments, macronutrient balancing and base applications of micronutrients does the development and application of biological products warrant evaluation. Humic acids and soil microbials have been available for many years, mostly under the label of "snake oils". Part of this reputation is earned by radical claims of NPK reduction and little or no emphasis to soil chemistry basics such as calcium & CEC. Another part of this reputation stems from the poor availability of credible scientific information. Furthermore, crop yields are pushed to higher levels today than they were in past decades.

At Bio-Gro, Inc., we recognize the importance of soil microbiology management by pointing out practical examples such as the increased production in "virgin" soils. If it were only nutrients and disease control, why can't we even produce a steady 75% of virgin soil production? The answer lies in regulation and management of soil and root microbiology.

Although we have many practical solutions to soil microbiology management, it is part of our approach to maintain "demonstration" applications of microbial products and to assure proper financial returns. This is done on a crop-by-crop and customer-by-customer basis.

**Step Ten – Development of Plant Stimulants:** as with soil microbials, the need for increased production quantity, quality and efficiency opens the door to utilize new and improved methods of crop production. Ironically, there are numerous published papers and patents describing untold methods and means of technology applications. What remains to be understood is that plant manipulation is the most effective means of overcoming soil deficiencies and increasing plant yields.

For example, some soils are so high in free lime (calcareous) that applying enough sulfur to neutralize the pH is not only too expensive, but would put the soil out of balance. Few fertility experts realize the common sense of supporting the excretion of natural plant organic acids to acidify the important zone of soil next to the root. This is often less than 5% of total soil capacity, furthermore, most plants have the ability to produce and excrete more acid per acre than even the wealthiest growers can afford to apply. The secret is simply learning how to trigger the plant to produce this effect. This is accomplished through plant nutrition and plant stimulant applications.

For example, we have found that it is possible to utilize near excess amounts of nitrogen (with proper excess emphasis on calcium, boron, sulfur & potassium) and still have a strong, natural maturity process. This is accomplished by foliar application of specific elements at specific pH levels with plant growth hormone precursors.

The list of potential is endless. However, we must stress the need for proper soil and plant nutrition first. Plant stimulants, like microbials, will be developed on a demonstration/needed/crop basis.