OPTIMAL PLANT NUTRITION

Thomas Yamashita's remarkable Patents (US05549729 and US05797976) provide one of the best primers on the missing corollary to von Liebigs Law of limiting nutrients(*), namely the practical implementation of ALL the key NUTRITION factors in plant nutrition.

(One must however, also consider the key SOIL LIFE factors.)

(*) von Liebig's hypothesis states that plant growth is limited by a single resource at any one time; only after that resource is increased to the point of sufficiency can another resource enhance plant growth.

The principles expounded in Yamashita's Compensatory Balanced Nutrition CBN] Theory are the basis of numerous of the "magic mushes"(**) which on occasion deliver outstanding 50-200% crop increases.

(**)Those based on Bargyla Rateaver's observation that "Seaweed has all a plant could possibly want, since it lives in the ocean where it has total access all the time to everything in totally absorbable state" include : HIBRIX™, Nutri-Kelp, Eco-Seaweed, Kelpak, Cornish Calcified Seaweed, Sea Grow, Spray Grow, Ocean Brew, 5500 Pressure Catalitic, ACADIE, Ocean Organics, Foliafeed, Betta-Crop, GA14, Etherics, ALGAENZIMS, AMINOLOM ALGAS, Maximaster Trace.

HIBRIX™ is distinguished by major supplementation with a Chelator/Sequestrant to carry the nutrients, apart from the use of land as well as sea plant extracts and supplementation of specific trace elements, vitamins and plant hormones to achieve a balanced formulation.

Traditional plant nutrition has, to date, approached remedial programs through a chronological path of observation, tissue and/or soil analysis, diagnosis, followed by remedy. Such an approach presupposes and accepts certain natural-occurring phenomena as limitations, the realm in which the plant must necessarily function:

1. That the plant must operate within and as such is constrained by an array of existing environmental factors such as climate and weather, the atmospheric concentration of carbon dioxide (0.03%),

duration and intensity of light, the seasons, limiting edaphic factors, etc.

2. That the plant must obey certain natural "time" frames of growth and reproduction.

3. That traditional irrigation, fertilization and pest control strategies will express the full potential of a plant's growth and reproduction.

4. That the application of some predetermined, deficient nutrient(s) at a specified time and rate will restore the plant to its optimal condition.

5. That the plant is totally resigned to "autotrophism" and as such must conform to this mode of growth, alone.

Yamashita commences on the energetics of Nitrogen, the keystone of amino acids, the building blocks of life :

"Both trivalent nitrogen, e.g. in the form of ammonia or a compound which is readily convertible to ammonia such as urea, and pentavalent nitrogen such as a nitrate are plant nutrients and sources of the macronutrient N.

Trivalent nitrogen in the form of ammonia or urea requires much less energy for assimilation than does pentavalent nitrogen in the form of nitrate. The reduction of nitrate to ammonia using NADH as an energy source requires 198 Kcal per gram mole and further steps in assimilation require approximately 51 Kcal, making a total of about 249 Kcal.

If the nitrogen is added in the form of ammonia or urea, an energy saving of about 198 Kcal would be accomplished.

While the use of trivalent nitrogen may appear remedial in conserving the plant's energy load, the application of purely reduced N forms may be harmful. It has been shown that the rapid assimilation of ammonia can place a sudden drain of both carbon skeletons and energy upon the plant.

In the presence of abundant carbohydrate reserves, this may not pose a problem. However, the rapidity with which assimilation can occur oftentimes depletes existing reserves to dangerously low levels. This latter physiological state of low carbohydrate:N (CHO:N) ratio may then promote highly vegetative and little reproductive growth.

Furthermore, the ammonium ion can inhibit photosynthetic electron transport systems.

In this latter case, then, sole reliance upon ammonia forms of N can be somewhat toxic to the plant. Urea forms can be quickly converted via urease to ammonia and thus are subject to similar considerations.

Additionally, heavy concentrations of urea may act to denature proteins by breaking sulfhydryl bonds and disrupting the tertiary structure of the molecule. If the protein is an enzyme, the denaturation process may potentially disrupt an entire cascade of biochemical reactions.

It is important, then, that a balance between the pentavalent and trivalent forms of nitrogen is maintained during applications to plants. The soil environment offers a degree of buffering due to microbial conversions of ammonia to nitrate forms, but the tri and pentavalent balance is especially important during foliar applications.

These ratios preferably range from 10 mols of trivalent N to 90 sole of pentavalent N to 90 solo of trivalent N to 10 close of pentavalent N and most preferably should stay close to a 50:50 ratio.

The importance of balanced nitrogen is heightened even more during applications of anions such as phosphates or sulfates, for example, as these require additional energy outlays for absorption.

When the nutrients are applied during periods of physiological stress and low metabolic efficiency, then, the plant must literally suffer additional stress.

All such factors further emphasize the importance of a carbon skeleton/energy component applied in conjunction as a compensatory factor, providing both energy and carbon skeletons during a critical, physiological, ebb in the life of the plant.

An example of a current used technique to enhance growth and/or crop production of plants and of its limitations is as follows: Nitrogen added as a fertilizer or plant nutrient may be in the form of pentavalent (oxidized) nitrogen such as a nitrate or in the trivalent (reduced) form such as ammonia or urea.

Assuming that the nitrogen applied to a plant is converted to a protein in which the nitrogen is trivalent, if the form of the nitrogen added is a nitrate it must be converted to the trivalent form which requires a considerable expenditure of energy over and above what is required if the nitrogen is applied in the form ammonia or urea.

The energy required must come from tissues of the plant directly or through photosynthesis. This would indicate that the application of nitrogen as ammonia or urea would place less demand upon the plant. However the application of nitrogen wholly as ammonia or urea has or may have disadvantages such as:

1. A sudden drain of both carbon skeletons and energy.

2. As a result of the condition created in 1, a low carbohydrate:nitrogen ratio promoting vegetative but marginal reproductive growth.

3. Inhibition of photosynthetic electron transport by the ammonium ion.

4. Urea-mediated denaturation of proteins through disruption of sulfhydryl bonds.

Another approach is to add a carbohydrate, such as sugar, directly, for example by a foliar spray of a sucrose or other water soluble, assimilable form of carbohydrate. The sugar, when absorbed into the leaves, will provide a source of energy and also a source of carbon skeleton from which, for example, proteins can be synthesized by the plant.

This can be, and often is, a very expensive way in which to apply a source of energy and of carbon skeleton. Also if carbohydrate fractions, alone, are added to the plant, various minerals would be needed to compensate for corresponding demands on balanced physiology.

Under greenhouse conditions using daily, complete nutrient fertilizers (such as Hoagland's Solution) and a full range of controlled climatic and other environmental factors, the otherwise sudden physiological imbalances brought on by carbohydrate additions alone could be mollified.

Resultingly, this would tend to be manifested in increased growth responses. Under actual field conditions, however, these same isolated additions of beneficial carbohydrates would tend to create offsetting physiological imbalances and would not manifest in full the potential benefits of these treatments.

In accordance with the invention there is applied to plants by a suitable route, at suitable times during growth of plants or their crops and at suitable intervals, a composition containing suitable amounts and proportions of the following:

One needs to calculate the energy units within plant tissues of an hypothetical, superior plant; (e.g., fruits, nuts, supportive tissues). This involves the assigning of a calorie value to carbohydrate (CHO), protein and/or fat constituents; the standard free energy of formation of one gram of CHO or protein is approximately 4.1 Kcal and one gram of fat 9.3 Kcal. In many cases the CHO, protein and fat constitutions of several crops can be obtained from published literature. When these are unavailable, standard laboratory analyses will provide the information needed.

Support tissues such as shoots are examined empirically and their mass estimated as approximately 60% of the wet weight. These tissues are all assigned a CHO caloric value as they are almost entirely of cellulitic constitution.

Standard procedures for estimating shoot growth is conducted by actual counting of the number of current year shoots on a secondary scaffold. The number of secondary scaffolds are then multiplied by the total number of primary scaffolds. This resultant value is multiplied by the number of shoots originally counted to obtain the total number of new shoots per tree (for smaller plants, the entire plant or a larger fraction can be counted).

Ten of the largest sized shoots are removed and their wet weight determined. The average weight is multiplied by the total number of shoots and 60% of this value is used as an estimate of the shoot growth. Shoot growth expressed in grams is then multiplied by 4.1 Kcal to arrive at the energy value of these tissues.

Because observations of root growth are difficult, an ideal root:shoot ratio of 0.8 is used to estimate the growth and caloric contribution from the roots (i.e. the energy value of shoot growth is multiplied by 0.8 to obtain the root growth caloric value).

The combined caloric values of reproductive and support tissues now represents the estimated energy units within the hypothetical superior plant.

The contribution of the primary macronutrient, nitrogen (N), is estimated from protein constituents. To estimate the contribution on N in proteins, Yamashita uses a value of 20%, based upon the N in a typical amino acid, lysine. For example, if almonds are made up of 40% protein, then, one pound [454 g] of almonds contains 36.3 g N (454x0.40x0.20=36.3).

The resultant value is doubled to account for nucleic acids, hormones and related compounds which also contain N. This quantity of N represents an estimate of the minimal annual requirement of N.

Quantities of N estimated as above are assigned energy of assimilation value, eg approximately 249 Kcal are required to assimilate one gram molecular weight of N.

The nature of N sources (primarily nitrate vs ammonia forms) may alter the kilocalories required for assimilation (249 Kcal required to assimilate nitrate vs 51 Kcal for ammonia) of N.

However, energy of assimilation values are derived from biochemical reactions leading up to the incorporating of N into one protein. This does not take into consideration alternate paths of transaminations and/or biochemical transformations.

Thus, Yamashita elects to utilize the energy of assimilation values in relation to utilizing nitrate as a sole N source as this is a more realistic estimate of actual energies utilized by a plant in assimilating N.

The sums of energy requirements calculated as above, then, represent the theoretical energy demand for the hypothetical superior plant one hopes to achieve.

The solar energy harvesting capacity of the untreated plant is estimated. To obtain this, the following are necessary:

1. Estimate of leaf surface area in square meters; the number of leaves are counted from a tertiary or quaternary scaffold (small plants may be counted in their entirety) and multiplied by the appropriate factor; the total number of leaves is multiplied by the area of a typical leaf.

2. About 5.78 Einsteins of energy will strike a square meter in one hour; this is equivalent to approximately 250 Kcal/square meter/hour (note: this considers an average sunny summer day).

3. Yamashita uses a 10 hour day and the number of equivalent sunny summer days during the growing season of the plant.

Total leaf surface.times.total hours.times.43.2 Kcal/sq. meter/hour are multiplied to obtain the potentially harvestable energy.

The Solar Kcal value obtained above represents the potential harvestable solar energy. However, actual photosynthetic efficiency of plants runs between 0.5%-3.5%. Percentage designation is based on the following table:

Maximum Photosynthetic Rates of Major Plant Types Under Natural Conditions

Type of Plant	Approximate Photosynthetic Efficiency	Example	Maximum Photosynthesis(**)
			mg CO_2/dm^2/hour
CAM (Crassulacian acid metabolism) succulents	0.50%	Agave americana	1 to 4
Tropical, subtropical mediterranean evergreen trees and shrubs; temperate zone evergreen conifers	1.00%	Pinus sylvestris	5 to 15
Temperate zone deciduous trees and shrubs	1.25%	Fagus sylvatica	5 to 20
Temperate zone herbs and C-3	2.00%	Glycine max	15 to 30

pathway crops			
Tropical grasses, dicots and sedges with C-4 pathways	3.50%	Zea mays	35 to 70
(**) Larcher, W [1969] Photosynthetica 3:167-198			

Thus, the Solar Energy value estimated above is multiplied by the appropriate efficiency to obtain actual harvest solar energy per season.

The energy demand is then subtracted from the actual harvestable solar energy.

If the value is negative, this represents a deficit in energy which must be compensated to achieve the hypothetical superior plant.

For a deficiency of energy units. the programming of a nutrient mix is based on the following criteria:

1. Early spring growth should be applied as a 4-5% Total Invert Sugar concentration

2. Later growth can be treated with 8-10% Total Invert Sugar solutions.

The specific goals of a program will dictate frequency of applications, e.g. if one is trying to overcome alternate bearing in pistachios it is critical that at least 3 applications are applied between early April and mid-May when the shoots bearing next year's fruit buds will be determined.

As a general rule, pre-log and logarithmic phase growth periods are most demanding of energy and nutrients, followed next by the linear and senescence phases as set forth by W. G. Whaley, 1961, in W. Ruhland, ed., Encyclopedia of Plant Physiology, Volume 14, Springer-Verlag, Berlin, pp. 71-112.

Most of the carbon skeleton-energy sources such as sucrose and will have entered the plant tissues within 4 days.

Yamashita has observed that under spring and summer conditions most plants will manifest noticeable growth 10-14 days following application of his formulation [Bright Sun].

These new tissues not only represent rapidly metabolising centres, but their relative succulence in combination with this factor facilitates absorption of Bright Sun. It is known that microscopic passage canals, the ectoteichodes, provide communication channels with the outside environment and thus are avenues for absorption of compounds and elements.

With the appropriate use of surfactants it may be possible to get materials through the stomata as well. Further, actively transported compounds, which thus require ATP, may gain additional help by the increased oxygen absorption induced by both "salt respiration" and added metabolizable energy units.

Nonetheless, taking advantage of rapidly metabolising, succulent tissues further enhances material absorption and this factor serves as a sound basis for instituting 10-14 day repeat application schedules.

Additionally, by 10-14 days localised depletion of elements and/or energy may begin to appear. It is necessary, then, to compensate for the induced increases in metabolism by periodic applications until the plant is conditioned (about midpoint or further beyond the linear phase of growth) to operate for the remainder of the season at its induced, higher, efficiency level. The more applications per season, the more benefits to the plant.

Yamashita provides lists of Assimilable Carbon Skeleton/Energy components :

sugar-mannose, lactose, dextrose, arythrose, fructose, fucose, galactose, glucose, gulose, maltose, polysaccharide, raffinose, ribose, ribulose, rutinose, saccharose, stachyose, trehalose, xylose, xylulose, adonose, amylose, arabinose, fructose phosphate, fucose-p, galactose-p, glucose-p, lactose-p, maltose-p, mannose-p, ribose-p, ribulose-p, xylose-p, xylulose-p, deoxyribose, corn steep liquor, whey, corn sugar, corn syrup, maple syrup, grape sugar, grape syrup, beet sugar, sorghum molasses, cane molasses, calcium lignosulfonate, sugar alcohol-adonitol, galactitol, glucitol, maltitol, mannitol, mannitol-p, ribitol, sorbitol, sorbitol-p, xylitol, organic acids-glucuronic acid, a-ketoglutaric acid, galactonic acid, glucaric acid, gluconic acid, pyruvic acid, polygalacturonic acid, saccharic acid, citric acid, succinic acid, malic acid, oxaloacetic acid, aspartic acid, phosphoglyceric acid, fulvic acid, ulmic acid, humic acid, nucleotides and bases-adenosine, adenosine-p, adenosine-p-glucose, uridine, uridine-p, uridine-p-glucose, thymine, thymine-p, cytosine, cytosine-p, guanosine, guanosine-p, guanosine-p-glucose, quanine, guanine-p, NADPH,NADH, FMN, FADH.

The addition of sucrose in foliar sprays, for example, is known to improve the plant in a number of ways:

1. Delaying senescence

2. Increases the number of plastids per cell (including chloroplasts and mitochondria)

3. Increases thylakoid formation

4. Increases thylakoid polypeptides

5. Increases cellulose synthesis

6. Increase the rate and amount of organic acids secreted by roots, thus improving the ability to extract mineral elements from the soil

7. Increases the rate of differentiation of cells

8. Stimulates cyclic AMP formation, thus regulating intracellular metabolism leading to increased enzyme activity and overall metabolic efficiency.

Yamashita's list of Macronutrient components includes :

N : ammonium nitrate, monoammonium phosphate, ammonium phosphate sulfate, ammonium sulfate, ammonium phosphatenitrate, diammonium phosphate, ammoniated single superphosphate, ammoniated triple superphosphate, nitric phosphates, ammonium chloride, aqua ammonia, ammonia-ammonium nitrate solutions, calcium ammonium nitrate, calcium nitrate, calcium cyanamide, sodium nitrate, urea, urea-formaldehyde, urea-ammonium nitrate solution, nitrate of soda potash, potassium nitrate, amino acids, proteins, nucleic acids

P : superphosphate (single, double and/or triple), phosphoric acid, ammonium phosphate, ammonium phosphate sulfate, ammonium phosphate nitrate, diammonium phosphate, ammoniated single superphosphate, ammoniated single superphosphate, ammoniated triple superphosphate, nitric phosphates, potassium pyrophosphates, sodium pyrophosphate, nucleic acid phosphates, X-potassium chloride, potassium sulfate, potassium gluconate, sulfate of potash magnesia, potassium carbonate, potassium acetate, potassium citrate, potassium hydroxide, potassium manganate, potassium phosphate, potassium molybdate, potassium thiosulfate, potassium zinc sulfate

Ca : calcium ammonium nitrate, calcium nitrate, calcium cyanamide, calcium acetate, calcium acetylsalicylate, calcium borate, calcium borogluconate, calcium carbonate, calcium chloride, calcium citrate, calcium ferrous citrate, calcium glycerophosphate, calcium lactate, calcium oxide, calcium pantothenate, calcium proprionate, calcium saccharate, calcium sulfate, calcium tartrate.

Mg : magnesium oxide, dolomite, magnesium acetate, magnesium bensoate, magnesium bisulfate, magnesium borate, magnesium chloride, magnesium citrate, magnesium nitrate, magnesium phosphate, magnesium salicylate, magnesium sulfate

S : ammonium sulfate, ammonium phosphate sulfate, calcium sulfate, potassiumsulfate, magnesium sulfate, sulfuric acid, cobalt sulfate, copper sulfate,ferric sulfate, ferrous sulfate, sulfur, cysteine, methionine
Yamashita Micronutrient components include :

Zn : zinc oxide, zinc acetate, zinc bensoate, zinc chloride, zinc citrate, zinc nitrate, zinc salicylate, ziram

Fe : ferric chloride, ferric citrate, ferric fructose, ferric glycerophosphate, ferric nitrate, ferric oxide (saccharated), ferrous chloride, ferrous citrate ferrous fumarate, ferrous gluconate, ferrous succinate

Mn : manganese acetate, manganese chloride, manganese nitrate, manganese phosphate

Cu : cupric acetate, cupric butyrate, cupric chlorate, cupric chloride, cupric citrate, cupric gluconate, cupric glycinate, cupric nitrate, cupric salicylate, cuprous acetate, cuprous chloride

B : calcium borate, potassium borohydride, borax, boron trioxide, potassium borotartrate, potassium tetraborate, sodium borate, sodium borohydride, sodium tetraborate

Mo : molybdic acid, calcium molybdate, potassium molybdate, sodium molybdate

In Yamashita's preferred CBN composition, the following additional components are also present:

Vitamin/cofactor components :
The most important are folic acid, biotin, pantothenic acid, nicotinic acid, riboflavin and thiamine. Others may be omitted but their presence is preferred.

Thiamine : thiamine pyrophosphate, thiamine monophosphate, thiamine disulfide, thiamine mononitrate, thiamine phosphoric acid ester chloride, thiamine phosphoric acid ester phosphate salt, thiamine 1,5 salt, thiamine triphosphoric acid ester, thiamine triphosphoric acid salt, yeast, yeast extract

Riboflavin : riboflavin acetyl phosphate, flavin adenine dinucleotide, flavin adenine mononucleotide, riboflavin phosphate, yeast, yeast extract

Nicotinic acid : nicotinic acid adenine dinucleotide, nicotinic acid amide, nicotinic acid benzyl ester, nicotinic acid monoethanolamine salt, yeast, yeast extract, nicotinic acid hydrazide, nicotinic acid hydroxamate, nicotinic acid-N-(hydroxymethyl)amide, nicotinic acid methyl ester, nicotinic acid mononucleotide, nicotinic acid nitrile

Pyridoxine : pyridoxal phosphate, yeast, yeast extract

Folic acid : yeast, yeast extract, folinic acid

Biotin : biotin sulfoxide, yeast, yeast extract, biotin 4-amidobenzoic acid, biotin amidocaproate N-hydroxysuccinimide ester, biotin 6-amidoquinoline, biotin hydrazide, biotin methyl ester, d-biotin-N-hydroxysuccinimide ester, biotin-maleimide, d-biotin p-nitrophenyl ester, biotin propranolal, 5-(N-biotinyl)-3 aminoallyl)-uridine 5'-triphosphate, biotinylated uridine, 5'-triphosphate, N-e-biotinyl-lysine

Pantothenic acid : yeast, yeast extract, coenzyme A

Cyanocobalamin : yeast, yeast extract

Phosphatidylcholine : soybean oil, eggs, bovine heart, bovine brain, bovine liver, L-a-phosphatidylcholine, B-acetyl-g-O-alkyl, D-a-phosphatidylcholine(PTCn), B-acetyl-g-O-hexadecyl, DL-a-PTCh,B-acetyl-g-O-hexadecyl, L-a-PTCh, B-acetyl-g-O-(octadec-9-cis-enyl), L-a-PTCh, B-arachidonoyl, g-stearoyl, L-a-PTCh, diarachidoyl,L-a-PTCh, dibehenoyl (dibutyroyl, dicaproyl, dicapryloyl, didecanoyl, dielaidoyl, 12 diheptadecanoyl, diheptanoyl), DL-a-PTCh dilauroyl, L-a-PTCh dimyristoyl (dilauroyl, dilinoleoyl, dinonanoyl, dioleoyl, dipentadeconoyl, dipalmitoyl, distearoyl, diundecanoyl, divaleroyl,B-elaidoyl-a-palmitoyl, B-linoleoyl-a-palmitoyl) DL-a-PTCh di-O-hexadecyl (dioleoyl, dipalmitoyl, B-O-methyl-g-O-hexadecyl, B-oleoyl-g-O-hexadecyl, B-palmitoyl-g-O-hexadecyl), D-a-PTCh dipalmitoyl, L-a-PTCh, B-O-methyl-g-O-octadecyl, L-a-PTCh, B-(NBD-aminohexanoyl)-g-palmitoyl, L-a-PTCh, B-oleoyl-g-O-palmitoyl (stearoyl), L-a-PTCh, B-palmitoyl-g-oleoyl, L-a-PTCh, B-palmitoyl-a-(pyren 1-yl) hexanoyl, L-a-PTCh, B(pyren-1-yl)-decanoyl-g-palmitoyl, L-a-PTCh, B-(pyren-1-yl)-hexanoyl-g-palmitoyl, L-a-PTCh, B-stearoyl-g-oleoyl

Inositol : inositol monophosphate, inositol macinate, myo-inositol, epi-inositol, myo-inositol 2,2' anhydro-2-c-hydroxymethyl (2-c-methylenemyoinositol oxide), D-myo-inositol 1,4-bisphosphate, DL-myo-inositol 1,2-cyclic monophosphate, myo-inositol dehydrogenase, myo-inositol hexanicotinate, inositol hexaphosphate, myo-inositol hexasulfate, myo-inositol 2-monophosphate, D-myo-inositol 1-monophosphate, DL-myo-inositol 1-monophosphate, D-myo-inositol triphosphate, scyllo-inositol

PABA-m-aminobenzoic acid, O-aminobenzoic acid, p-aminobenzoic acid butyl
ester, PABA ethyl ester, 3-ABA ethyl ester

Yamashita's Enhancement agent components include :
1. Complexing Agents :
Citric acid; Ca, K, Na and ammonium lignosulfonates, fulvic acid, ulmic acid, humic acid, EDTA, EDDA, EDDHA, HEDTA, CDTA, PTPA, NTA.

2. Growth Regulators
Seaweed extract-kelp extract, kinetin, kinotin riboside, benzyladenine, zeatin riboside, zeatin, extract of corn cockle, isopentenyl adenine, dihydrozeatin, indoleacetic acid, phenylacetic acid, indole ethanol, indoleacetaldehyde, indoleacetonitrile, gibberellins (E.g. GA1, GA2, GA3, GA4, GA7, GA38 etc.)

3. Gum Components
Xanthan gum-guar gum, gum agar, gum accroides, gum arabic, gum carrageenan, gum damar, gum elemi, gum ghatti, gum guaiac, gum karya, locust bean gum, gum mastic, gum pontianak, gum rosin, gum storax, gum tragacanth

4. Microbialstats
Proprionic acid, benzoic acid, sorbic acid.

5. pH Buffers
phosphate buffer-acetate buffer, AMP buffer, calcium tartrate, glycine buffer, phosphate citrate buffer, tris buffer Yamashita also discusses the role of nutrition in protecting the plant against various stresses, including :

1. Normal events such as flowering where the demand for carbohydrates increases and places a demand on the root system of the plant, causing the roots to be depleted of their normal concentration of carbohydrates.

2. Climate, fay also play a part in stress. For example, if sunlight is below normal during the growing season and photosynthesis is thereby diminished, the plants may have to draw upon their reserves to sustain flowering, flower setting or fruit setting and saturation.

3. Pathogens such as for example verticillium and fusarium, nematodes, etc. or pests such as sites and aphids may also create stress. For example, verticillium and fusarium tend to plug the vascular tissue of plants, thereby preventing absorption of water and resulting in wilting.

Another example of benefit of the invention is a situation where a pathogen causes stress. Verticillium and fusarium colonies plug vascular tissue and prevent absorption of water. A plant can counteract the incipient infection by walling off the pathogen through production of phenylpropanoids, phytoalexins, lignin, suberin, to name a few.

The effective defense response requires the immediate production of enzymes, m-RNA and various carbon skeleton-energy compounds. A successful defense response is rate-related, depending largely upon production and placement of the walling off compounds in advance of the pathogens growth through the host. But where, due for example to a period of stress, the plant tissue is low in carbohydrates and energy, this walling off process is impeded. By applying the composition of the invention, for example as a foliar spray, the vigor of the plant is sustained and walling off occurs in advance of the pathogen.

4. Another example of physiological stress is typified by cotton and other plants with rather massive, luxuriant canopies. Within these canopies, on hot days, the ratio of oxygen to carbon dioxide increases due to plant metabolism. If, as is the case with cotton, the plant is what is known as a carbon 3 plant in which an event in metabolism is the assimilation of carbon dioxide at the alpha carbon of ribulose bis phosphate, oxygen competes with carbon dioxide for this position via a process known as photorespiration.

Periods of high light, high temperature and concomitantly higher ratios of oxygen to carbon dioxide favor photorespiration. This results in lowered photosynthetic efficiency as well as both energy and mass accumulation reductions.

5. Yet another type of physiologically stress may occur where a fertilizer is applied to the soil or to foliage. This fertilizer, especially a nitrate, requires energy for reduction to trivalent nitrogen. In the case of nitrate, this is as such as 198 Kcal per gram molecular weight of N. Energy is also required for assimilation into the plant. While reduced forms of nitrogen (as with ammonia or urea forms) may have lower energy demands for assimilation, the rapidity with which they can be assimilates places a sudden demand on carbohydrates within the plant.

Thus fertilization, by virtue of sudden energy and carbohydrate demands, may have a detrimental effect through this additional stress.

Such period of physiological stress may be detected by observation or by analytical methods, via monitoring instruments or they may be predictable on the basis of experience.

6. Frost concerns represent one of the limiting factors in plant agriculture.

Many liquids, including water, can be supercooled below the melting point of the solid phase. Freezing occurs thereafter either spontaneously or in the presence of a catalyst. The catalysts are often referred to as ice nuclei, the two general types of which are classified homogeneous and heterogeneous. Homogeneous nuclei are important below -10 C, while heterogeneous nuclei come into play above this range. Of primary importance to agriculture are freezing temperature ranges between -5 to 0 C. It is at these temperatures that many plant tissues are damaged. That is, supercooling does not occur due to the presence of nuclei catalyzing the liquid to solid transition.

Within this initial freezing range of -5 and 0 C, it has been found that three primary epiphytic bacterial species serve as ice nucleation catalysts (Pseudomonas syringae, ps. fluoresecens, Erwinia herbicola). The bacteria are normal inhabitants colonizing the plant surfaces. It is believed that certain constituents located on the cellular membrane initiate ice formation bringing about freezing and plant tissue damages. Resultingly, programs directed at reducing the populations of ice nucleation bacteria have provided a significant degree of frost protection. Three general avenues of achieving these goals are via the use of:

a. Bactericides

b. Ice nucleation inhibitors

c. Antagonistic bacteria

These approaches relate to findings of a log-linear relationship between frost injury to plants (at a specified temperature) and the quantity of ice nuclei associated with the plant. The lower the population of ice nucleation bacteria, then, the sore opportunity for supercooling in the absence of ice formation.

Of the three methods, the use of antagonistic bacteria offers a highly viable and economical means of achieving frost protection. It exercises the principles of microbial ecology of the phylloplane. The soil environment has multiple niches and buffer zones, which contribute to ecological diversity. However, the phylloplane has fewer dimensions and resultingly its extent of diversity is more with respect to time or seasons. An epiphytic bacterial species which aggressively colonizes surface tissue, then, encounters few natural obstacles other than variations of moisture and temperature. Thus, once started, a particular colony can be difficult to displace.

A logical approach, then, would be to introduce large populations of antagonists following:

1. Previous natural decline of ice nucleating species

2. Bactericidal applications to reduce ice nucleating species

To date investigators have overlooked two key factors for successful introduction of an antagonistic bacterial species:

1. Conditioning the antagonist

2. Providing a temporary substrate on plant surfaces for expansion and an interim for adaptation.

The methods developed by Yamashita address these issues.

PERSISTENT HERBICIDES IN COMPOST: KILLERS ON THE LOOSE

By Chrys Ostrander

Back in the summer of 2000, folks involved with community gardens in Moscow and Pullman began noticing plants dying in their vegetable gardens.

Farmers in the Northwest and elsewhere around the country reported similar problems. "I usually add 7 tons of finished compost per acre as either a soil conditioner or as mulch for weed control", says Art Biggert of Ocean Sky Farm on Bainbridge Island, WA. "This year I was shocked to see what appeared to be herbicide damage in one of my pole bean cultivars and my tomato crops. They had deformed shoot and leaf development, significantly decreased and delayed bloom and fruit development."

Since the summer of 2000, researchers at Pennsylvania State University have documented widespread herbicide contamination of finished compost products manufactured by the University.

Beans, potatoes, sunflowers, squash, tomatoes and other plants shrivel up and keel over on affected farms and gardens.

After some good detective work, the community gardeners south of Spokane traced their problems to contaminated compost they had gotten from the research compost facility at Washington State University in Pullman.

The culprits were found to be two persistent herbicides, clopyralid and picloram, both manufactured by DOW AgroSciences, and used on farms, in city parks and on residential lawns.

The discovery caused quite a stir. Suddenly, not only could WSU not sell its compost, incurring over $250,000 in losses, but the Spokane Regional Solid Waste System, which relies on sales of compost from their Colbert, WA composting facility, was left with tons and tons of compost they could not sell either.

Additionally, several organic farms suffered de-certification due to the contaminated compost, with WSU paying them compensation for their losses.

Clopyralid and picloram are weed killers that keep on killing, season after season. Their longevity and extreme potency (studies show toxic effects to sensitive plants at concentrations as low as one part per billion for clopyralid) are their big selling points.

Picloram is an active ingredient found in products intended for use in hay crops and is still active in animal manure after passing through the intestines of cattle fed on pasture that has been sprayed with it, even after the manure and bedding has been composted.

Clopyralid, on the other hand, is found in several products used for broad-leaf control in turf-grass maintenance and row crop production.

But as with many chemically derived "great ideas", there's a very dark side to these miracles of modern chemistry. Not only do they persist through the composting process to kill the plants in your garden, they are dangerous poisons.

According to the Journal of Pesticide Reform (Winter 1998), published by the Northwest Coalition for Alternatives to Pesticides, "clopyralid and the products containing it are irritating to eyes, some severely.

The eye hazards include permanent impairment of vision or irreversible damage. In laboratory tests, clopyralid caused what a U.S. Environmental Protection Agency (EPA) reviewer called "substantial" reproductive problems.

These include a reduction in the weight of fetuses carried by rabbits who ingested clopyralid, an increase in skeletal abnormalities in these fetuses at all doses tested, and an increase in the number of fetuses with hydrocephaly, accumulation of excess fluid around the brain.

Wow! And it could be in the compost destined for your garden!.

According to the Journal of Pesticide Reform, "In laboratory tests, picloram causes damage to the liver, kidney, and spleen. Other adverse effects observed in laboratory tests include embryo loss in pregnant rabbits and testicular atrophy in male rats. The combination of picloram and 2,4-D causes birth defects and decreases birth weights in mice. Picloram is distinguished even more by being one of the few "legal" pesticides known to be contaminated with the carcinogen hexachlorobenzine. Hexachlorobenzine is a highly toxic chemical that persists and bio-accumulates in ever-increasing levels in the food chain and fatty tissues, causes reproductive abnormalities at very low doses and is easily transferred from mother to infant through breastmilk.

Hexachlorobenzine was used, until it was banned worldwide, as a seed fumigant. It killed scores of nursing infants in Turkey after a mass poisoning of grain in the late '50's.

Picloram and clopyralid are found in various products with a wide array of brand names. The most common, made by DOW, are Pathway and Tordon (contain picloram) and Confront, Curtail and Stinger (contain clopyralid).

Characteristics of a Healthy Soil Foodweb, Per Gram of Soil:

Good compost will have on the order of a 1,000 million bacteria per teaspoon (109 bacteria per teaspoon). Most of these individuals are beneficial to plant growth, and do not cause disease.

600 million bacterial individuals, 15,000 to 20,000 species

150 to 300 meters of fungal biomass, 5,000 to 10,000 species

Fungi produce humic acids, and thus a significant humic acid component should be present. If an extract of the compost is made, a rich dark brown color should occur. If the color is light or tan in color, few humic acids have been produced, only fulvic acids, indicating mostly bacterial activity.

Mycorrhizal fungi do not grow in compost. The heating process kills most of the spores, and those remaining are not usually viable. It is usually of some benefit to add an inoculum of mycorrhizal spores to compost. The food resources present in compost may cause mycorrhizal spores to germinate after a few days (72 hours for example). If the germinated spores do not find active roots within 24 to 48 hours of germination, they die. Therefore, spores should be added to compost just before planting.

10,000 protozoa

Protozoa go through boom and bust growth cycles in compost, depending on the temperature and on the presence of their bacterial prey. As the compost heats, the protozoa encyst to escape the high temperature. When the compost cools, the protozoa excyst and become active again. As compost moves into the maturation phase, protozoa may reach 100,000 to 1,000,000 per teaspoon. Mature compost should only contain 10,000 to 50,000 protozoa.

Flagellates and amoebae do not tolerate anaerobic conditions and will be killed by lack of oxygen. If the compost becomes anaerobic at any time, flagellates and amoebae will be lost. They are good indicators of this aspect of good compost.

20-30 nematodes : Bacterial-Feeding, Fungal-Feeding and Predatory
Like protozoa, nematodes don't like heat or anaerobic conditions.

Many of the beneficials and all of the root-feeding nematodes will be killed by the heating process. But a reasonable number of the beneficial nematodes should survive the heating process to wake-up when the temperature drops below 135 F. The beneficials then begin to grow, and given the presence of huge numbers of bacteria and fungi, reach high numbers in a few weeks. It is important, however, to know the time-since-135 F, since if temperature drops rapidly, only a few beneficial nematodes could be expected, as their life-cycles are a minimum two-weeks in duration.

Good compost will contain 30 to a hundred beneficial (bacterial-feeding, fungal-feeding and predatory) nematodes per gram of material. Really great compost may contain several hundred beneficial nematodes per teaspoon.

There should be no detectable root-feeding nematodes present in good compost. If they are found, it indicates that parts of the compost did not remain above 135 F for the entire composting cycle time. In general, roots feeders appear to be more sensitive to temperature than beneficial nematodes, especially when they are not protected by the presence of live roots. If any root-feeding nematode eggs survive the heat cycle and hatch during compost maturation, they should be consumed by predatory nematodes, but nematode-trapping fungi, by microarthropods, and fungal nematode parasites. If perchance they are not, the lack of live roots in the compost should cause them to succumb.

200,000 arthropods per square meter

However, the organisms in compost should match the needs of the plant.
Bacteria-dominated compost is also best for applying to the soil before growing vegetables, herbs, turf, lawns, and row crops.

There are several reasons:
1. Bacteria produce "slime layers" around their bodies, which they use to glue themselves to surfaces.
This prevents them being washed out of the soil, so they retain nutrients in the soi l. But this slime layer is most often made of alkaline materials, which may cause soil to become more alkaline.

2. Bacteria are eaten by protozoa and bacterial-feeding nematodes, releasing ammonium into the soil.

In alkaline conditions, maintained by the slime layers and secondary metabolites that bacteria produce, nitrifying bacteria thrive and convert ammonium to nitrate quite rapidly.

Nitrate is the preferred form of N for most row crops, grasses and vegetable crops.

Thus, these plants grow best in bacterial-dominated soils.

Fungi-dominated compost is good for mulching around berries and fruit trees.

Trees, shrubs and many perennial plants do best in fungal dominated soil, for the following reasons:

1. Fungi make organic acids as their waste products.

2. Fungi are eaten by fungal-feeding nematodes, a few species of large amoebae, and fungal-feeding microarthropods.

Fungal-predators release N in the form of ammonium.

Because fungi maintain soil pH on the acidic size, and indeed, beneficial fungi appear to buffer soil pH between a pH of 5.5 and 6.5, nitrifying bacteria are excluded from the foodweb.

While there are a few species of nitrifying fungi which are found in unique places (the oak savannas of California, for example), the majority of N in fungal dominated soils are present as ammonium, not nitrate.

Trees, shrubs and many perennial plants, as demonstrated by J. Stark and also by Marschener, grow more efficiently when using ammonium, instead of nitrate.

The "pool" of inorganic N in healthy forests is dominated by ammonium, while the inorganic N pool in grasslands is dominated by nitrate.

However research has shown that a foliar spray of bacteria-dominated compost tea is extremely useful to prevent the foliar diseases that plague most gardens.

Thus, most of us need only be concerned with making a bacteria-dominated compost tea.

Thus for the best growth of different plants, there needs to be recognition that the organisms in the soil will set conditions that select for maximum or optimal plant growth. This is not to say that plants can't grow in sub-optimal conditions, but it does suggest that plant growth will be stressed in these conditions, and that disease will be a greater factor in stressed plants.

But probably the most generally useful compost would have balanced bacterial and fungal biomass, since then the plant would select for dominance of the microorganisms most beneficial to it. As broad a diversity of both bacteria and fungi would also be beneficial, regardless of what system into which the compost will be placed.

The balance of easy-to-use N (which bacteria like for growth) to hard-to-use C (which fungi like for growth) will determine a great deal of the composting process.

Easy-to-use C and N materials will select for bacterial growth, while hard-to-use C and N will select for fungal growth.

The Basic Bacterial Starting Recipe

For bacteria to dominate, compost should be made from a preponderance of green materials. You need a mix of 25 percent high-nitrogen ingredients, 45 percent green ingredients, and 30 percent woody material. High-nitrogen materials include

For bacterial compost, start with:
25% high N material, such as manure(*) and legumes, such as alfalfa, pea, clover, or bean plant residues.

45 to 50% Green material includes any green plant debris, kitchen scraps, and coffee grounds, which, although brown in color, contain sugars and proteins that bacteria love. Grass clippings from the first two or three cuttings in spring, when the blades are lush and tender, qualify as high-nitrogen; the rest of the season, they're simply green material. (avoid material to which pesticides were applied), and 25 to 30% woody, brown, dry leaf, straw, hay, bark materials, wood chips, sawdust, paper plates and towels, and shredded newspaper.

(*)If the manure is stinky, wet, or runny, reduce the amount of manure used. It is quite likely that this manure will be high in salts and will result in phytotoxicity. Use only 10% manure and increase the percent green and woody materials.

The Basic Fungal Starting Recipe

For fungal compost, start with:
5-10% hi N material, such as alfalfa or manure (see below about different kinds), 45-50% green leafy material (avoid material to which pesticides were applied), and 40 - 50% woody, brown, dry leaf, straw, hay, bark materials.

Trial-and-error is important to improve the compost beyond the basic recipes given above.

If your compost heated too fast, you have too much juicy, N-rich green stuff.

Reduce its volume in the next batch by perhaps 10%.

If pile #2 doesn't heat enough, increase the amount of juicy, N-rich stuff by 5%.

Too hot again? Add more straw.

Keep adjusting until you can make a pile that needs little turning, but gets to temperature and stays there for 15 days, then comes down to ambient, and gives no further heating even when turned.

But of course before there is a plant to optimally nutrition, it has to be propagated. And with results flowing in from related testwork; a new product, HIBRIX PROPAGATIONTONIC™, has been developed to maximize the efficiency of propagation has been formulated.

May this product bless you
with improved Yields
and improved Crop Quality.