Animal, Human and Soil Health in Relation to the Nutrient Stabilization Process

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Introduction

For thousand of years it has been known that the food with the highest nutritional value for mankind and animals is taken from plant that have been harvested and then eaten immediately. Vine ripened fruits contain many times the nutritional value of foods that have been harvested green and then allowed to ripen (Bear, Firman). Therefore, nutritionally speaking, the problem with current plant harvesting, distribution, and storage methods is that significant deterioration occurs. The loss of some metabolic enzymes, up to 80%, occurs within the first ten minutes of harvesting. Man has created useful, innovative ways to preserve foods through dehydrating, canning, freezing, and adding preservatives. Yet, Nature still has the best storage system. This is found inside the seed! Stable, long chain carbohydrates and starches allow the seed to remain in a quiescent period for years or even decades. Also, beneficial trace elements are stored in seeds at concentrations at least two hundred times their concentrations in other plant material (Betschar, 1988)

Human beings have problems digesting these long chain molecules: the digestion rate is only approximately 5%. Cattle however, having the most complex digestive tract, digest approximately 53% of the rolled and crushed seeds, and that is when digestive enzymes have been added. For this reason, scientists, for the past 80 years, have experimented with feeding germinating seeds to animals, since germinating seeds naturally have a digestibility of 97% with animals. During the germination time, the plant regulators and enzymes that are produced convert the carbohydrates and starches into simple sugars and amino acids that increase the digestibility up to 97%. Nonetheless, studies have shown inconsistencies, with exceptional results 50% of the time but either negative or no beneficial results the other 50% of the time.

Finney (1983) conducted an extensive review of the effect germination has on the nutrient value of cereals and legumes. He stated that his review was based on nearly 100 years of chemical studies and about 70 years of corroborative rat and other animal feeding studies; that these animal studies had been further corroborated by a few well-documented human feeding studies; and that he relied on hundreds, and in some cases, thousands of years of experience by millions of people. Finney concluded that carefully controlled, optimal germination of edible cereals and legumes is capable of significantly alleviating today’s problems and avoiding tomorrow’s food needs

Finney’s statement provides a strong challenge to develop an understanding of how the process of germination can be used as a “tool” to improve the feeding value of grains. Variation in germination is expected, as there can be many genetic and environmental factors (e.g., temperature, light, moisture, and time) that control germination (Bau et al., 1997), and ultimately the “benefits” of germination.

Typically, for cereal grains, germination is described as the time that radical emergence occurs. In barley, radical emergence may take 48 or more hours to occur. Pre-germination is defined here as the time between imbibition (water uptake by the seed) and radical emergence. Based on the information found in the literature, it would appear that the majority of the studies involved germinated (post radical emergence) and sprouted seeds. In our own initial studies we have used pre-germinated grains.

Based on experiences with malt (Cornell and Hoveling, 1998), the minimum requirement for germination of barley was the absorption of 40% of its weight in water. To maximize and equalize germination of malt barley, it was necessary to facilitate equal oxygenation and maintain an optimum constant core temperature. During germination, dormancy oft the embryo is broken and the embryo releases growth regulators that trigger the release of enzymes such as phytase, amylases, proteases, and phosphorylases. These enzymes then act on the grain, particularly on endosperm components (Cornell and Hoveling, 1998). The enzymes break down the starch and complex carbohydrates producing more soluble proteins.

The control of seed quiescence, or dormancy, is generally classified in one of five ways: rudimentary embryos; physiologically immature embryos (inactive enzyme systems); mechanically resistant seed coats; degree of impermeability of seed coats; and presence of germination inhibitors (Pomeranz, 1992).

Duration of dormancy in most cereal grains is largely determined genetically. Nevertheless, dry and sunny weather during grain development will shorten the post harvest dormancy. Other influences of dormancy affecting the seed coat integrity are total days to harvest, soil mineral content, cultivation practices, and other environments stress factors during the growth period. Grain quality and yield is further determined by assessing the complete ecosystem the mother plant has been associated with during her life cycle.

Conventional practices to break dormancy include, predrying at 35C; treating with gibberellic acid or hydrogen peroxide; or scarifying (mechanically or chemically removing) the outermost layers of the seed coat. It has been observed that the germination of wheat, reduces the allergic response manifested by humans with “gluten” allergies. It has also been observed that when barley is stored after harvest, this storage improves chick broiler performance (Fuente et al., 1998). Other studies revealed that different soaking times and different water temperatures affected the enzyme activity in barley such that the germinated barley did not require enzymes to improve broiler performance (Svihus, 1997). More information is needed on the physio-chemical factors that control seed dormancy and that consequently affect nutrition and health.

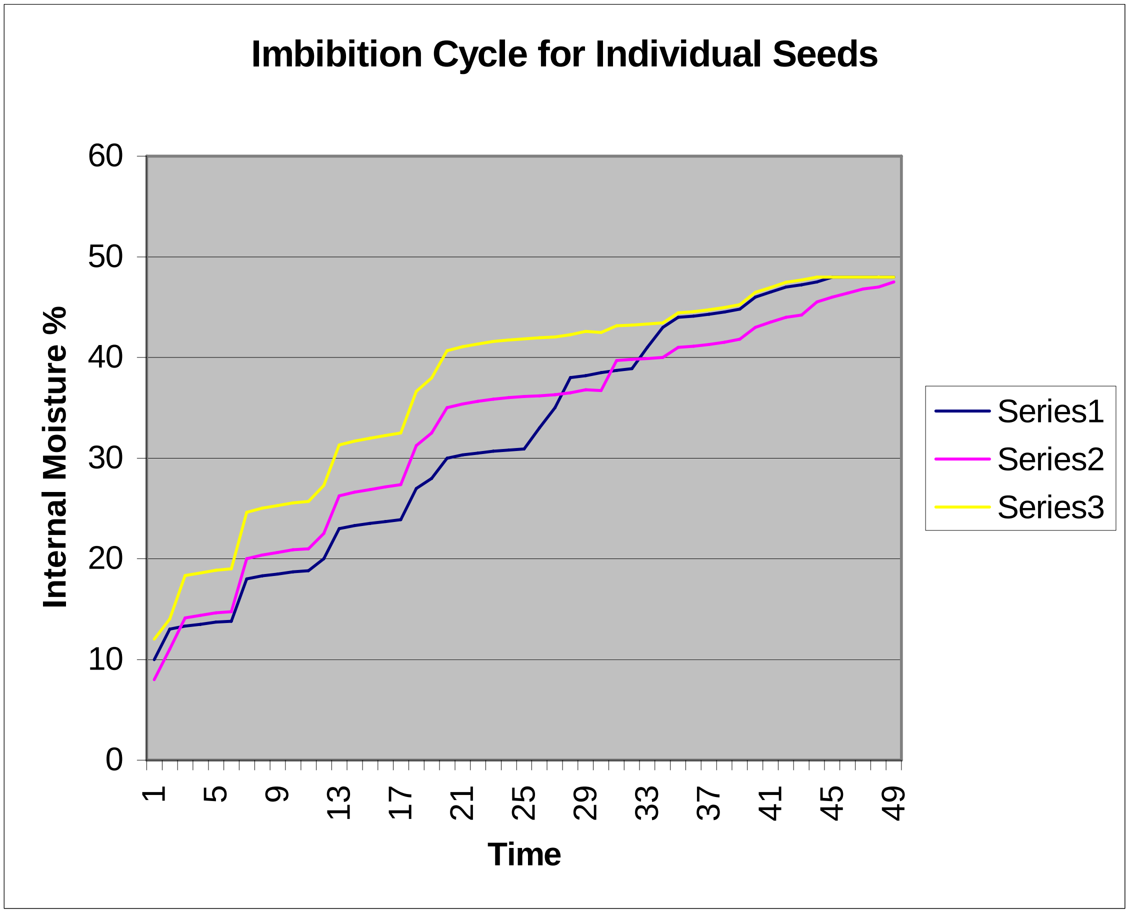
With regards to the germination of grains and legumes to improve the food/feed value, Finney (1983) listed four criteria that need to be: which conditions result in the most seed constituents being “converted” into required nutrients; which conditions minimize microbiological infestation; which conditions maximize the growth and production of the seed; and which conditions result in minimal seed nutrient loss and maximal absorption of water-soluble constituents from the steep and germination medium. Current germination enhancement compounds, such as giberellin salts, nitrites, ammonium salts, calcium, and polyethylene glycol, have a direct impact on the seed’s production of and uptake of nutrients. A unique process, the Germination Enhancement Method (G.E.M.™), provides superior results but utilizes a mechanical procedure to cause imbibition rather than a soaking procedure to initiate germination. Seed germination is synchronized through priming the seed (drying the seed back). This results in an increase of the plant protein levels and an increase of the digestibility of the product.

The G.E.M.™ pre-germination process and N.S.P.

The Growth Enhancement Method (G.E.M.™.) process, which evolved from years of testing in laboratories and in the field, concluded that the synchronization of germination was critically important. Since enzyme development varies at different times, the fact that seeds within the same plant germinate at different times causes conflicts, and these conflicts partially explain certain negative results. The G.E.M.™ process was initially developed to produce superior, drought hardy, primed forage, and turf and reclamation grass seed.

The G.E.M.™ process is a seed priming procedure used by Breakthru Seed Enhancement Corporation on turf and forage species to enhance germination and subsequent establishment. Priming is a process whereby the chemical process of germination is initiated through the sequential imbibition and drying of seed. Previous studies, using germinated seeds for animal feeding, have shown erratic responses. Hence, a secondary process called the Nutrient Stabilization Process, or N.S.P., was developed to stabilize the highly digestible nutrients after the G.E.M.™ priming procedure. In developing the G.E.M.™ and N.S.P. processes, it was observed that in order to initiate sequential germination in a composite sample of seed, the individual seed required different internal moisture levels to optimize development (Figure 1).

Figure 1 Variable internal moisture conditions of individual seeds during germination.



Most priming techniques involve seed soaking procedures with the use of organic salts to compensate for the irregular moisture uptake of the different seeds. Since the seeds are immersed in a water bath, leachate is released from the seed, thereby lowering seedling vigor and providing an optimal medium for bacterial growth. Osmotic conditioning is very cumbersome, as each lot requires a different ratio of organic salts due to variance of seed lot maturity. The resulting primed seed or sprouts are not synchronized, evidenced by the inconsistent enzyme concentrations in the different lots. Since material is generally fed in a dried form, the irregular growth and subsequent irregular enzyme production increases food value deterioration.

Table 1

Nutritional Values

Regular Barley Vs. Nutrient Stabilized Barley®

Test	Regular Barley * 5% Digestible	N.S.P. Barley *97% Digestible	Difference	% Change
Crude Fiber	5.50%	**3.80%**	**(1.70%)**	-31%
Crude Fat	1.90%	**1.80%**	**(0.10%)**	- 5%
Ash	2.80%	**2.20%**	**(0.60%)**	-21%
Crude Protein	9.00%	**10.20%**	**1.20%**	13%
Available Protein	8.90%	**9.40%**	**0.50%**	5%
Soluble Protein	2.80%	**4.70%**	**1.90%**	68%
Available Insoluble Protein	6.20%	**4.80%**	**(1.40%)**	-22%
Non-Structured Carbohydrates	62.40%	**66.50%**	**4.10%**	6%
ADIN (nitrogen)	0.02%	**0.13%**	**0.11%**	550%
ADIN (protein)	0.13%	**0.81%**	**0.68%**	523%
Acid Detergent Fiber	23.90%	**19.30%**	**(4.60%)**	-19%
Nitrogen Free Extract	80.80%	**81.90%**	**1.10%**	1%
Total Lipids	34.4 g	**36.6g**	**2.20g**	6%
Calcium	0.07%	**0.05%**	**(0.02%)**	-28%
Phosphorus	0.43%	**0.39%**	**(0.04%)**	- 9%
Magnesium	0.16%	**0.15%**	**(0.01%)**	-6%
Potassium	0.50%	**0.52%**	**0.02%**	-4%
Salt	0.03%	**0.03%**	**0%**	0%
Sodium	0.01%	**0.01%**	**0%**	0%
Copper	4 ppm	**6ppm**	**2ppm**	50%
Iron	83 ppm	**66 ppm**	**(17 ppm)**	-20%
Manganese	17 ppm	**32 ppm**	**15 ppm**	88%
Zinc	39 ppm	**45 ppm**	**6 ppm**	15%
Alanine	0.42 g	**0.39 g**	**(0.03)g**	- 7%
Amino Butyric Acid	0.61g	**1.00g**	**0.39g**	64%
Arginine	5.89g	**6.32g**	**0.43g**	7%
Cystine	1.81g	**1.55g**	**(0.26)g**	-14%
Glumatic Acid	23.7g	**23.1g**	**(0.60)g**	- 2%
Glycine	4.76g	**4.39g**	**(0.37)g**	- 8%
Histidine	3.02g	**2.91g**	**(0.11)g**	- 4%
Isoleucine	4.01 g	**4.12g**	**0.11g**	3%
Leucine	7.84g	**8.15g**	**0.31g**	4%
Lysine	3.98g	**4.02g**	**0.04g**	1%
Methionine	2.05g	**2.05g**	**0.00g**	0%
Phenyalanine	7.37g	**6.26g**	**(1.11)g**	-15%
Proline	10.5g	**11.3g**	**0.08g**	<1%
Serine	5.14g	**4.10g**	**(1.03)g**	-20%
Threonine	4.52g	**3.33g**	**(1.19)g**	-26%
Valine	4.86g	**5.14g**	**0.28g**	6%
Fatty Acid % of Total Triglycercide				
Linoleic	57.4%	**58.10%**	**0.70%**	1%
Linolenic	6.02%	**6.38%**	**0.36%**	6%
Oleic	14.40%	**13.10%**	**(1.30%)**	- 9%
Palmitic	21.30%	**22.00%**	**0.70%**	3%
Stearic	0.69%	**0.55%**	**(0.14%)**	20%

The G.E.M.™ process overcomes the guessing aspect of seed priming since each seed is always treated as an individual. The basic laws of germination are followed and the scarification, vernalization, and germination sequences are followed so that all dormancy factors are broken. Though each seed has its own unique imbibition cycle, all seed is synchronized through their natural rhythms. This synchronization of the germination process provides uniform development of all the seeds to the point of greatly enhanced digestive and metabolic enzyme content without compromising the nutritional content of the seeds.

The Nutrient Stabilization Process (N.S.P.) was subsequently developed to address the problem of stabilizing our synchronized, germinating seeds in mass. It enables the pre-germinated grains to maintain higher protein and enzymatic activity for up to six months rather than, as with conventional processing, an average time of 10 minutes. During our extensive experimentation, done in conjunction with Agriculture Canada at Agassiz, it was realized that the N.S.P. food produced a healthier, more productive bird compared to conventional nutritional formulas (Pomeranz Y., 1992). These results subsequently led to the development of the Barley Gold product for humans. See Table 1 for these comparisons.

Animal Studies using pre-germinated grain at PARC (Agassiz)

Three preliminary studies have been conducted to evaluate the effect of pre-germination of cereal grains on broiler chick performance in the Agassiz broiler chick bioassay. The initial study compared control (not germinated) and G.E.M.™ (pre-germinated) barley with and without a commercial enzyme (Avizyme-SX, Finnfeeds Intl., Marlborough, UK). The second study tested 24 treatments, based on six-grain sources that were fed "as is" or after G.E.M.™ pre-germination with and without an appropriate enzyme. The third study measured the performance of broiler chicks, housed in floor pens and fed conventional diets that contained a portion of G.E.M.™ pre-germinated barley.

The initial Agassiz broiler chick bioassay (Scott et al., 1998) concluded with six points regarding the birds:

1. All N.S.P. fed broilers were leaner but heavier.
2. All N.S.P. fed broilers had higher red and white blood cells.
3. All N.S.P. fed broilers had stronger more developed hearts.
4. All N.S.P. fed broilers had higher bone density.
5. All N.S.P. fed broilers had higher intestinal viscosity.
6. All N.S.P. fed broilers consumed more N.S.P. fed.

The initial Agassiz broiler chick study (Scott et al., 1998) concluded with four points regarding the N.S.P. barley.

1. Protein values were increased.
2. Soluble protein values were increased.
3. Digestibility of material was increased to 97%
4. Additional enzymes were not necessary to aid digestion.

Svihus (1997) also determined that the endogenous enzymes released during germination attributed for the reduced need for added enzymes.

Pomeranz (1992) observed that destroying the biological order by changing water adsorption capacity and reactivity may enhance damage from other sources, such as oxygen, light, and high relative humidity. The G.E.M.™/N.S.P. treated barley exhibited damage only when exposed to high relative humidity.

These animal results were astounding. The obvious next question was, “Could these results also be accomplished with humans?”

Intestinal health is the basis of total whole health. The intestine is the first organ to die when not receiving correct nutrition. An unhealthy intestine cannot transport the necessary nutrition to the rest of the body. It is theorized that the Nutrient Stabilized barley’s highly digestible nutrients, along with the digestive and metabolic enzymes, can initiate intestinal cleansing and healing.

The N.S.P. barley’s enhanced digestibility transports more amino acids and nutrients to the organs. This enables the body to heal as well as to rid itself of toxins and wastes effectively. The body responds, through its sensitized ecosonoid metabolism, by causing individuals to crave this new food and other highly nutritious food, thereby providing the body with more building blocks to rejuvenate further. It appears that by providing the body with highly nutritious, natural components, the body can heal and revitalize it's self.

Hippocrates once said, “Good food is the best medicine and the best foods are the best medicines.”

N.S.P. Treated Barley for Humans – Barley Gold

Currently, a human product has been launched and is marketed under the name of Barley Gold. The results have been very promising. There have been extraordinary testimonies of improved health physically, mentally, and even emotionally. The age groups that have been targeted have been those over forty years of age or individuals exhibiting serious health problems. Aches, pains, low energy, and many other debilitating conditions are their concerns. The enhanced barley seems to start the healing chain reaction. The same positive results occur in humans as those that occurred in broiler chickens. Osteo-arthritics have had bone mass increased and mobility restored. Cholesterol has been reduced and circulatory systems are improved. Intestinal disorders are minimized and healing is initiated. Depression has been reduced and headaches are minimized (particularity in men). Immune systems have been fortified and energy improved (Haynes, 2002.)

Reports from the medical community as to the needs of the human body revealed to us that most of the components necessary were present in the enhanced barley product. See Table 1. Interesting also, is that research has shown that ADD, ADHD, depression, manic depression and schizophrenia are in part a result of insufficient nutrient absorption (Synergy Group of Canada Inc., 1997). School breakfast and lunch programs have proven to increase student grades. Similar research would be beneficial in senior citizen institutions, with the goal of reducing the health care costs and increasing quality and productive lives.

G.E.M.™ and N.S.P. for Food and Plant Production

The results and the potential for not only increasing seed nutritional value but also for testing the N.S.P. encouraged us to process other plant material. Initial testing on other seed varieties and plant material has shown exceptional results. It appears that if the N.S.P can be utilized at the time of harvest, it can stabilize vine-ripened nutrient content for up to five months.

However, each seed and plant variety appears to have a different N.S.P. sequencing. The optimum biological transmutations for humans or animals need to be tested and verified. Nutritional content of food could be increased and field spoilage decreased. The G.E.M.™ process allows for virtually immediate germination, growth synchronization, and specific plant fertilization. Using the N.S.P. in conjunction with the G.E.M.™ process will lower costs and increase production. G.E.M.™ tests have concluded that under specific management a stronger root system is developed. This lowers environmental stress factors, such as insufficient water or nutrients, and increases plant competitiveness, while minimizing erosion and building the soil organic matter. The stronger plants compete for nutrients more efficiently, resulting in higher bushel weights and, thus, higher nutrient values. The change of the growth regulator sequencing in a primed seed naturally increases root development, which may be an asset or a liability to the potential grower. It is important to understand the changes in the seed and the changes to the plant growth patterns in different environments. Concerns have been divided into three groups: soil, site management, and existing vegetation. Addressing these concerns requires a complete ecological approach to assess the chemistry, soil pedogenesis and plant succession. All are interrelated and require different management strategies to optimize success. Prior to treatment, it is important to understand the environmental bent of the area that is being considered. This is best explained through the plant acclimation factors outlined in the Ecological Soil Management system.

Finney (1983) four criteria that need to be considered to improve food/feed value are all addressed with the G.E.M.™ process. The N.S.P. then complements the G.E.M.™, resulting in the achievement of optimal levels of nutrition and stabilization. Furthermore, future generations of harvested can have their quality increased because of the G.E.M.™ process increasing subsequent plant quality and quantity. These beneficial qualities are outlined in Table 2. Additional positive results are consistently reflected in animal bioassay tests and digestive and chemical analyses.

Table 2

TABLE 1995 ACID TOLERANT ALFALFA TEST, FORAGE YIELD

CULTIVAR	1996YIELD (Kg/ha)	% of BEAVER
GEM AC Blue "J"	**1,797**	**114%**
Beaver	1,574	100%
Rambler	1,554	99%
Apica	1,447	92%
Sure	1,370	87%
Anchor	1,321	84%
Algonquin	1,311	83%
Impact	1,311	83%
Rangelander	1,272	81%
Grimm	1,243	79%
Multileaf	1,214	77%
Multistar	1,195	76%
88 R 52	1,166	74%
OAC Ninto	1,166	74%
AC Blue"J" Non GEM	1,156	73%
Legend	1,098	70%
Spredor II	1,068	68%
Peace	1,010	64%
NS MO3	923	59%
Heinrichs	796	51%
Anik	690	44%
Melrose	359	23%
Marino 2	185	12%
Norlac 2	185	12%
Nova 1	175	11%
Mean	1063	
F Value	5.05	

1=Sainfoin
2=Clover

Low yield results in Sanfoin and Clover varieties are a result of deer and elk grazing (sainfoin), and prostrate varietal habit(clover).
1 year results from Agriculture Canada Research Station Lethbridge Alberta.

Ecological Soil Management (E.S.M.) System

Soil

Soil formation, or pedogenesis, is directed by such influences as the parent geological material, weather, biological factors, aspect or land undulation, and the natural hydrological features of the land. In redeveloping a site, all or a multitude of combinations of the above factors influence the changes in soil fertility that then occur. Problems such as disease resistance and plant vigor are directly related to soil dynamics. Being cognizant of these signs enables the supervisor to implement management procedures, thus developing uniform soil dynamics and uniform plant growth.

For a point of reference it is imperative to determine the present chemical, biochemical and pedogenic states. Chemical analysis is determines the current elemental composition of the soil. The pedogenic state is determined by either a current soil classification (only if major landscaping has not occurred) or by examining municipal records of soil classifications prior to any disturbance. This provides information as to the natural fertility and soil dynamics of the site.

From each of the soils analyzed, a complete macro and micro nutrient test should be taken, along with C.E.C., pH, organic matter, and texture analysis. Soil should also be examined for hardpan zones in the different soil horizons. Descriptions of the depth, structure and color are useful. Use of the "Ecological Soil Management," or E.S.M. system, to develop a Balanced Cycle, influences the soil pedogenesis dramatically and therefore soil tests can be confusing during the first two years. The assessment of soil chemistry commences the process of understanding the general composition; however, the biochemical reactions are very often not considered for any vegetative growth. A mapping of the transmutations and their relationship with other forms of biota form a matrix that will allow the manager of the soil to compensate for the desired vegetation with minimal inputs. A reading of Biological Transmutations by Louis Kervan should be completed to understand the reactions taking place.

Site Management

Management techniques provide information as to how the introduced factors influence the pedogenic dynamics. Fertilization and herbicide applications, irrigation design, irrigation frequency, equipment used, and maintenance sequencing, along with current usage description, all determine the soil fertility and thus the health of the vegetation to be grown.

Goals should be holistic, as in the E.S.M. system, oriented towards a Balanced Cycle approach that increases soil-buffering capacity. These goals should be the major objectives in stabilizing plant development. Chemical fertilizers affect the major component of soil development, that of the microbial populations. Nutrient balancing, along with spring soil inoculation of wanted microbes, would help eliminate a multitude of problems. Dramatic results can be seen. However, the complete soil changing process is slow and usually requires three years. The end result is a high buffering capacity with increased biocycling of nutrients, enabling the soil to produce strong, vigorous, disease resistant plants. It must also be noted that on some sites it is impossible to reach a point where one can relax. On such sites, constant input is necessary because of the natural soil dynamics. Once this base is built, fertilizer requirements are minimized, with the available nutrients being slowly and constantly released into the soil profile. G.E.M.™ seed, with its massive root system, can then monopolize the given areas.

Answers about current chemical usage of herbicides and pesticides help direct the nutrient-balancing scenario. By providing plants with nutritional balance, most can then develop a high resistance against pests and disease. A hostile environment is created for weeds, allowing the domesticated species to dominate the area. This is referred to as a state of fungistasis. For example, high nitrogen fertilization produces lush growth. When this plant cellular structure is not fully developed, the plants' succulent state invites pests and pathogens to invade, concluding with a final invasion of unwanted plant species that naturally have a resistance to the pathogens or pests at the higher nitrogen levels. Some plants will produce an allopathic response, but most species become dominant because of a state of soil fungistasis that affects the protein synthesis and thus the cellular structure of the plant (Albrecht, 1945).

With reference to irrigation management, the amount, quality, and frequency of irrigation are other indicators of root penetration. High water requirements, even after rainy weather, indicate a shallow root system. This is usually prevalent in areas that have had high nitrogen fertilizer applications. To break the endless cycle, both water and fertilizer requirements must be minimized. This is initiated in the fall with stimulants and soil conditioners that help maintain the desired microbial populations.

Other reasons for high watering are improper water penetration caused by a hardpan area, or poor water quality. These problems are more difficult to deal with, and can range from compacting caused by equipment to sites being located in water discharge zones.

Existing Vegetation

Vegetation in an area is understood by assessing either the plant acclimatization or the indicator weeds. Current vegetation mapping is an excellent way to determine the soil pedogenesis and soil fertility. If understood, favorable growth conditions and continued disease resistance can be accomplished. Investigating problem vegetation, by measuring root penetration and mapping both domestic and weed species that are present, is an important first step. Mapping is a dynamic process and therefore is dependent on the time of the year, the last herbicide application time, and the herbicide used. Application rates as compared to manufacturer's specifications will determine if resistance is being developed. Several years' data is excellent. The same breakdown on fungicide and pesticide applications should be determined.

Plant Acclimation and Seed Maturity Testing

In selecting a seed variety it is important to assess the natural genetic characteristics. Most plant breeders develop varieties that have consistent attributes but fail to understand specific ecosystem acclimation factors. It must be noted that 30% of plant development is determined by the plant's genetics, while its environment determines the other 70%. Landscape architects, horticulturists, and scientists know that the geographic origin of transplanted plants is significant for plant establishment. They also know that genetic variability is evident even with plants in similar stands. Seed produced is of variable size and quantity. This is because of the plant's individual response to changes in environmental regions and the plant's individual ability to compete within a stand for a finite amount of nutrients and light. Yearly, regional influences such as daylight length, date of last frost, soil pH, soil fertility, and humidity further influence genetically different populations within a given variety. Most of these ecological conditions in nature are evident as genotypes that move latitudinally through climatic zones and longitudinally through soil regions.

Seed diversification is inhibited because of the acclimation factors on the mother plant. Seeds are produced that naturally will grow best in soils similar to the parent. Nature's way of maintaining seed diversification is through seed maturity. The time and conditions of harvesting determine a multitude of genetic ranges and thus determine a multitude of soil and climatic ideals. Because of this complexity, seed maturity testing seems difficult, if not impossible. Presently the method of testing site mortality is costly. However, by pre-testing seed lots with the G.E.M.™ method, seed maturity can be matched with the soil types of the proposed site, minimizing failure. By providing data on specific sites and having a general regional breakdown, treatment conditions can further be modified to promote additional seedling vigor, thereby assisting plants to produce to their maximum genetic potential. By initially providing an optimum environment and determining the best seed for a site, the strongest growing plant is established.

Plant Succession Indicator Weeds

Mapping domestic species along with understanding weed development and pedogenesis allows one to be aware of problems in their initial stages and enables one to rectify the problems without major expense. Plant succession is nature's way of revitalizing the soil, thus transmuting elements back and forth to achieve the optimum environment for the next species. A soil analysis with a tissue analysis of the weeds that are developing in an area will expand the list below as well as determine the other transmutation relationships. These are some common weeds and what they tell us about soil conditions.

* **Bindweed** *(Convolvulus)* - crusted, tight soil, low humus.
* **Broomsedge** *(Andropogon virginicus)* - depleted, oxidized soil, low in calcium and possibly magnesium; poor soil structure; possible overuse of salt fertilizers.
* **Foxtail barley** *(Hordeum jubatum)* - wet soil, possibly high salts and low calcium, compacting, possibly acid, unavailable potassium and trace elements.
* **Common burdock** *(Arctium minus)* - high iron, acid, low calcium; also grows on high gypsum soil or from excess use of dolomite lime or ammonium sulfate plus lime.
* **Cheat, Chess** *(Bromus secalinus)* - wet, compacted, puddles (fine particles, no granular structure).
* **Chickweed** *(Stellaria media)* - high organic matter at surface, low mineral content.
* **Chicory** *(Cichorium intybus)* - fairly good soil, clay or heavy soil.
* **Cocklebur** *(Xanthium pennsylvanicum)* - fairly good soil with high available phosphorus, but may have low avail able zinc.
* **Crabgrass** *(Digitaria sanguinalis)* - tight, crusted soil, low calcium, inadequate decay of organic matter.
* **Dandelion** *(Taraxacum officinale)* - low calcium, organic matter not decomposing.
* **Dock** *(Rumex)* - wet, acid soils.
* **Fall panicum** *(Panicum dichotomitlforum)* - anaerobic, compacted soil.
* **Foxtail, giant foxtail** *(Setaria)* - tight, wet soil, possible high magnesium; seed germinates in anaerobic conditions (high carbon dioxide).
* **Horsenettle** *(Solanum dulcamara)* - crusted soil, low humus.
* **Jimsonweed** *(Datura stramonium)* - improper decomposition of organic matter (fermentation)
* **Johnsongrass** *(Sorghum halepense)* - depleted soil, low organic mater, low calcium, and possibly high iron
* **Lamb's quarters** *(Cheopodium album)* - rich, fertile soil; good decay or organic matter, high humus
* **Common milkweed** *(Asclepias syriaca)* - good soil, generally grows in fallow areas
* **Mustard (wild mustard, yellow rocket, wild radish, peppergrass, etc.)** *(Brassica, Raphanus, Lepidium)* - crust, hardpan, poor soil structure, poor drainage
* **Nettles, stinging nettle** *(Urtica)* - anaerobic, toxic soil, wrong decomposition of organic matter (fermentation)
* **Pigweed** *(Amaranthus),* **red root (rough pigweed)** *(Amaranthus retroflexus)* good soil
* **Purslane** *(Portulaca oleracea)* - fairly good soil
* **Quackgrass** *(Agropyron repens)* - wet, anaerobic soil, high aluminum (toxic); in West, low calcium and high magnesium and sodium
* **Red sorrel, Sheep sorrel** *(Rumex acetosell)* - acid soil, low calcium, low decomposition or organic matter
* **Russian Thistle** *(Salsola kali var. tenuifolia)* - salty soil (high sodium and potassium), low calcium and iron, low organic matter
* **Smartweed** *(Polygonum)* - wet, poorly drained soil
* **Thistles** *(Cirsium)* & **sowthistle** *(Sonchus oleraceus)* - fairly good soil
* **Tumbleweed** *(Amaranthus albus)* (Russian thistle is also called tumbleweed: see above) - dry soil, low humus
* **Velvetleaf (button weed)** *(Albutilon theophrasti)* - anaerobic soil, wrong decay of organic matter (fermentation)

Soil Chemistry and Biochemistry

In a true Balanced Cycle approach, it must be understood that soil fertility is dynamic and can change on its own. As soil is a living entity, we need to coach it along to where we would like it to be, to grow only the plants we want to live in it (see Indicator Weeds). Balancing of the soil's chemistry and biochemistry requires understanding of three interacting factors that change the soil's fertility. These are divided into Translocations, Transformations, or Transmutations of elements within the soil profile.

Translocation of nutrients is the movement of nutrients from one location to another. This is the most easily understood aspect of soil chemistry. An example is the natural cycle of the movement of nitrogen (N) from the air to living plants.

Transformation of nutrients is the change of the form of nutrients and is best explained by the assimilation of elements and subsequent release of these nutrients. This is called anabolism and catabolism. Anabolism is the growth cycle of the plant and catabolism is when the dead plant material is transformed back into the active soil components through a humification and mineralization process. Also, included in transformations is the less complicated concept of pH change and effect it has on immobilizing the nutrients within the soils. Though the concepts of translocation and the transformation may appear simple, these concepts are continually overlooked in conventional soil management. The misunderstanding of the contributions of soil organic matter is an excellent example. In conventional soil analyses, we note that soil organic matter (S.O.M.) is referred to as a percentage and is not calculated into total nutrients. To easily calculate the potential of S.O.M., remember that 6 inches of soil weighs approximately 2 million lbs. per acre. Therefore, one percent S.O.M. is equal to 20,000 lbs. per acre. Since grasses have a fifteen to one carbon to nitrogen ratio, one percent S.O.M. represents 1,333 lbs. of actual, slow release N. This should appear in the analysis as 665 ppm of N. Usually the N component is under 10 ppm.

The translocation of N can occur by virtue of the fact that 78% of the air we breathe is composed of N. A Balanced Cycle system would employ free-living N to fixate soil microbes, which translocate N from the air. Organic matter derives the majority of its nitrogen from this huge reserve in the atmosphere. (The balance is transmutated.) Tapping into this cycle with a comprehensive program eventually eliminates the need to purchase N in any form from fertilizer companies. Through transformations, this nitrogen is involved in the anabolism and catabolism cycle. Initially, transformations occur when nutrients are immobilized through the anabolic phase or the plant growth cycle. Catabolism, or the decomposition cycle of S.O.M., transforms the nutrients into usable humic and fulvic acids.

Increasing the S.O.M. is like having a savings account. Increases of 3.8 % S.O.M. represent 5,065 lbs. of slow release N/acre. In documented test results, this actually occurred over a two year period, representing 2,532 ppm additional N per acre! (Campbell, 1995).

Conventional management programs, or what is called the Balance Sheet approach, can only accomplish anabolism through the translocation of N fertilizers or of compost material. However, the E.S.M. achieves an equilibrium using free N fixating microbes, which in turn create the balanced ammonium to nitrate ratio. This is why the E.S.M. system is a true Balanced Cycle approach.

The pure chemist approach, in utilizing only a Balance Sheet strategy, is not complete. Nutrients within the S.O.M. are not acknowledged. In the attempt to balance the chemical components in the soil, miscalculations of nutrient requirements result. Yes, nitrogen fertilizers speed up catabolism, increasing growth for a short period. However, this decreases the S.O.M. immobilizing nutrient reserves, causing soils to harden. A vicious cycle then begins with continual increase of fertilizers, herbicides, fungicides, and pesticides in an attempt to increase soil fertility. The end result is a bankrupt soil that can only develop a vulnerable plant.

The E.S.M. system accomplishes a healthy soil through balancing the microbial populations, resulting in an increase or stabilization of S.O.M. A true Balanced Cycle approach exploits a deeper soil zone to mine and recycle nutrients. It causes anabolism and catabolism to increase and stabilize the S.O.M. reservoir, thus increasing the soil buffering capacity. Moisture retention is optimized by the decomposition of thatch. Through the minerialization or transmutation of Calcium (Ca) in the soil profile a strong non-digestible plant is developed.

Transmutation of nutrients is the changing of one element to another element. In the 19th century, chemists declared, “Nothing is created nor destroyed.” Through nuclear physics in the 20th century, Einstein proved, “Elements can be changed.” Welcome to the 21st Century! Using these principles for constructive transmutations make the job of managing the soil easier.

One very important element involved in the transmutations of soils is calcium. The following outline, in Diagram 1, shows the importance of S.O.M. decomposition in the transmutation of calcium. Once the S.O.M. decomposes, soils become aerobic, allowing the excess carbon to combine with oxygen and thereby create calcium. The humic and fulvic acids provide hydrogen ions that can combine with sodium to produce magnesium, or can combine with potassium to produce calcium. It is interesting to note that magnesium transmutations occur during the winter months and act as a cold sink. Potassium transmutations occur during the summer months and act as a heat sink. Magnesium levels are the highest during the spring when plants require magnesium for chlorophyll production. Potassium levels are highest in the fall when plants require potassium for winter hardening.

When minerialization occurs, there are increases and decreases in the different elements. To follow this, one must be working with the changes of the ppm of the elements. Understanding how pH, climate, and enzymes react makes the concept of transmutation easier to grasp.

It is imperative to comprehend these concepts for optimal soil management, with or without the use of G.E.M.^{TM} treated seed. The benefit of using G.E.M.^{TM} seed however, is that the massive root system that is produced initiates deeper soil uniformity and allows for more nutrients to be exploited. Balancing soil pedogenesis for crops helps the development of soil fungistasis. This challenge does not need to be accomplished with chemicals; it is better achieved through a holistic understanding of the proper crop rotation and soil management for the plant ecosystem to be cultivated. In other words, a comprehension of the current system is required. Then a Balanced Cycle approach must be implemented, to assess and develop a program that contours to the current soil pedogenesis, soil chemistry/biochemistry, and plant health G.E.M.^{TM} seed, the N.S.P., and the E.S.M. system, when used simultaneously, allow for these new benchmarks to be implemented and established.

Some Interesting Transmutations of Calcium

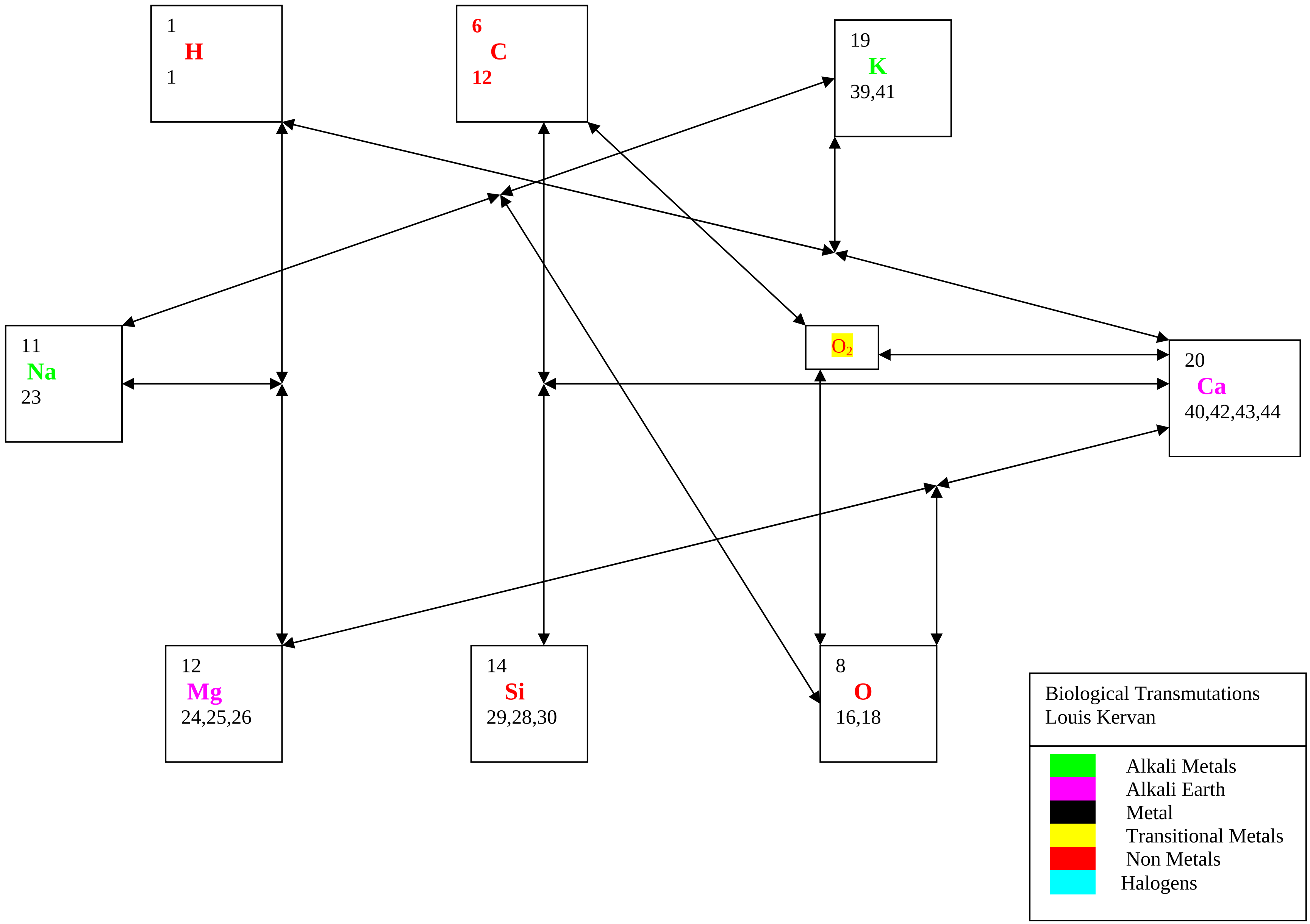


Diagram 1

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