COMMON QUESTIONS AND ANSWERS ABOUT

KOW CONSULTING ASSOCIATION'S PROGRAM FOR DAIRY NUTRITION FROM THE SOIL UP

By Tom Weaver

What is so special or unique about your approach to dairy nutrition and management?

I would say that it is the *big picture* approach to evaluation of a whole farm system that makes the difference and the unique approach to **connecting dairy nutrition to soil science**.

From my point of view, it is **logical** to consider the health of our soils when making management decisions. **DNFTSU** (Dairy Nutrition From The Soil Up) views soil not as mere dirt, but as a living entity and evaluates a soil's *health* considering three basic areas:

Chemical: Level and balance of Ca, P, Mg, K, S, Zn, Cu, Mn, B, etc. Note that a "chemical" is *not* a reference to pesticide selection. I don't know of any nutritional requirement for pesticide! Pesticides should be viewed as a last resort used only when necessary to prevent crop failure - much the way we *should* use antibiotics. If we take this balanced view these tools will likely work when we actually do need them! Our industry must wake up to the reality of *resistance.* We are currently *painting ourselves into a corner* with bio-tech and pesticides.

Physical: Structure, air/drainage, tilth, compaction, etc.

***Biological*:** Balance and numbers of active/beneficial earthworms, fungi, protozoa, and bacteria as can be evaluated by observing directly or by recycling of organic matter (or lack thereof), odor, and possibly bio-soil testing/culturing.

The chem-phys-biological aspects of the soil *are all interdependent on one another for optimum health* (as judged by productivity measured in plant growth *and quality*). **DNFTSU** considers evaluating a soil *only* for it's pH, P and K level to be *incorrect* or at best, very incomplete. **DNFTSU** views evaluation and care of biological life to be critical in making chemical nutrients available for plants (and in turn for making plants *nutritious* for cows).

Physical structure can have a great positive or negative effect on biology and chemical availability. Chemical balance can affect structure. Chemical balance can affect biology. We can't consider one without the others! **DNFTSU** considers monitoring biological life, because of it's sensitivity to our management practices, to be a good *barometer* for sustained success or impending failure.

Now just a word about the term *sustainable*: I simply believe it is *incorrect reasoning* to think that *non*-sustainable methods of management (soil, crop or cow) will provide *sustainable* success (as measured in yield, quality, animal productivity/health and ultimately profit). In order to have this *sustained* success *we must work with the natural system as it was designed*. Although I am not a *mother earth worshipping environmentalist*, I do believe in good stewardship. I do not believe in the theory of Darwinian evolution (*random mutation* resulting in intelligence and complexity of design) and therefore am of the opinion that natural systems were actually *designed* (by a wise Creator) to function a certain way and no matter how hard we want to <u>force</u> them to *adapt* to our desired methods/shortcuts, it is not going to produce long term success - *sustainability*. I do not consider all that is natural to be good or ideal. Good stewardship requires ***intelligent intervention.***

What do you mean by nutrition from the soil up and how does your approach differ from common nutrition programs?

DNFTSU describes a *system* of nutrition management that recognizes there are no short cuts to delivering proper nutrition to ruminant animals. This system recognizes the true complexity of the digestive process, that it is more than merely delivering numerical volumes of the chemical elements without regard to their form. This school of thought acknowledges that nature delivers these elements in specific organic complexes which must be manufactured by the plant.

Starting a nutrition program in the soil recognizes that following nature's design for providing nutrition is the most efficient system and most successful in regard to providing the nutrients to the animal *in a form which can be utilized*. **Soil is the plant's "stomach"** and this is where the digestive process begins. (There are amazing parallels that can be drawn comparing soil to the rumen of the cow!) If the plant's stomach is upset it will produce an unhealthy plant which will in turn ultimately lead to an unhealthy animal. On the other hand, healthy soils produce healthy feed crops that provide for healthy animals. To put it simply, this system of nutrition recognizes that the "root" of many *nutritional* disorders starts in the *soil* (no pun intended). Modern technology still cannot measure everything that needs to be measured -nor do we posses *complete* knowledge -and even if it could / did, we would not have the ability to *economically* manufacture nutrition in all the **organic** forms needed to make it useful to the animal.

The **DNFTSU** approach agrees with conventional nutritional knowledge when it comes to useful diagnostic information, i.e., deficiency systems/behaviors, etc., but it takes an entirely different view on the practical application of meeting nutritional needs. Here is a listing of some of the basic differences:

Conventional Nutrition [Information source: observation /study of industry practices and common recommendations.]	**Dairy Nutrition From The Soil Up** [Information source: observation / study of the soil, forage quality and cow response.]
We can *create* the ideal ration for the cow by calculating a few of the key chemical element needs and making up for any perceived deficiencies by adding feed supplements/ concentrates.	We can only assist nature to create the *ideal forage* for the cow through proper soil management and fertility and *it is via this pathway only* that we can feed optimum rations because as the forage goes, so goes the ration.
Maximum profit is achieved via aggressive "challenge" feeding that results in maximum milk per lactation. (Challenge feeding involves the inclusion of a high percentage of concentrates in the diet, especially in early lactation, with the intent to "*push"* the cow to maximum peak milk production. In theory, this	Maximum profit is achieved via maximum milk per acre driven by maximum forage *quality* (as well as yield). This approach makes possible the implementation of diet formulation that utilizes an unusually high percentage of *forage* to meet nutritional needs which in turn results in fewer nutritional disorders/healthier cows,

approach is *suppose to* yield significantly higher production through the remainder of the lactation curve. In practice it results in a significant reduction in the average lifespan of the cow.)	lower cull rates, greater cow longevity, more calves to raise or sell and *maximum lifetime milk production*.
We can accurately/precisely predict nutrient needs for on farm feeding situations by relying on the conclusions made from our university research models and assuming that the data and prediction equations derived from that data are applicable on private/for profit farms.	We cannot treat all farms as equal when calculating ration estimates due to the great differences in soil health (fertility and balance, biological life, physical structure) that affect forage quality, as well as the storage method herdsman skill / cow comfort, and other crop/cow management factors. These are all great variables that affect digestibility/nutrient bioavailability and it is impossible to put a numerical value on all factors involved.
If the cows are not performing up to the standards of the ration calculated, there must be something wrong with the cows or herd management. "According to our calculations, all nutritional needs are met and all cows should be producing impressive levels of milk." The cows should be performing to *our* standards. If they don't hold up under our program, "it must be a genetic weakness and they need to be culled anyway. In the meantime, call the hoof trimmer again and keep breeding for better feet and legs." [These statements may or may not be literally spoken on dairy farms, but they are certainly implied by much of the advice offered today. The problem I see today in the dairy industry is that the feed industry has grabbed a hold of *short term* research trial results in order to sell feed supplements, but the management strategies promoted are not in the *long term* best interest of the cow or the farmer.]	**Computer generated ration estimates carry the same degree of accuracy as the weather forecast.** If the cows are not responding or are responding negatively, troubleshoot in this order: 1. Question the assumptions (the ration estimate). 2. Question environmental/management factors. (Comfort, bunk space, etc.) 3. Question non-nutritional herd health factors (disease, etc.). *Short term* milk response is not the only criteria by which we can judge if a ration is balanced properly. The bottom line is that the herd is always the final judge. *We are required to perform according to the cows' standards*. Feed the cows to be *healthy* and keep them clean and comfortable, and they will be productive for us. **Any ration that ultimately has a negative effect on cow longevity is *not* a "balanced" ration.**
Rations can be most accurately balanced by modern computer software that has the ability to calculate a nearly unlimited number of nutrient variables.	Rations can only be "fine-tuned" by the herdsman who daily observes feed intake, cud chewing patterns, rumen fill / function, manure / digestion, etc. Basic principles and knowledge of rumen fermentation/function can normally be applied to correct most problems. It is impossible to juggle all the constantly changing factors involved in a biological system (the rumen fermentation) via the use of mathematical equations. Computers are helpful to make calculations, but are not necessary to provide accurately balanced rations.

Mineral levels and balance within the forage matter very little because we can simply add supplemental sources to make up any deficiency. It is not practical, to try to effect mineral balance in forage by altering soil fertility practices because it is much more *efficient* to use supplements. (Efficient does not necessarily *always* mean economical or effective!)	Mineral levels and balance in forage matter a great deal because forage is *not merely a vehicle* by which cows receive some of the minerals they need, but the mineral levels and balance effect *all* things in regard to quality within the forage (digestibility of fiber, sugar concentrations, usefulness of the "crude" protein, etc.). Furthermore, *organic* minerals found in forage are much more useful to the cow than are inorganic minerals found in a bag of supplement. *Fortunately mineral balance and uptake can be influenced via soil fertility management.*

What do you mean by balanced, healthy soil?

In regard to forage production it would be best to simply state that we should be interested in promoting a *chemical* balance in the soil that mimics the soils of the western states that have traditionally/ naturally grown high quality legume crops. I am of the school of thought that *there is an ideal chemical balance in soils* that produce *quality* legumes and high energy/digestibility grasses.

One of the measures I use as a guide is % base saturation (% cation exchange capacity or CEC) of soil cations (positively charged elements). CEC is a measure of a soils ability to store and release nutrients. You may like to refer to it as a measure of the size of *gas tank* a soil has. Sand may have only a 5 CEC (small gas tank) while a heavy clay soil may have an 18 CEC (big gas tank). **Here are ideals for the balance of major elements:**

Calcium: 70 to 85% of C.E.C. (Note: 400 x CEC x % saturation ÷ 200 = ppm)

Magnesium: 12 to 18% of C.E.C. (Note: 240 x CEC x % saturation ÷ 200 = ppm)

Potassium:* 3 to 5% of C.E.C. (Note: 780 x CEC x % saturation ÷ 200 = ppm)
**Low* CEC soils will need to be on the high end of the range for potassium.

Improving / changing the C.E.C. and the percent saturation of major cations should be a *long term* goal of your soil fertility program.

* Lighter soils of low C.E.C. will be changed faster than heavier soils with high exchange capacity. As you build organic matter via proper rotation and other management you will likely increase the C.E.C. of your soil *which will actually work against the rapid change of these percentages*. This should not discourage the pursuit of the goal.

* ***What is most important is that you recognize your limiting factors based on the percent base saturation of cations and adjust your fertilization practices* to meet the limiting nutrient needs while avoiding application of those already in adequate supply. In doing this, you will affect the available nutrient supply (that which comes readily into soil solution) to the forage crop in a way that will positively change it's**

quality as livestock feed. *Over time* you *will* see a change in the cation balance of your soil and there is enough independent lab results to prove it!

Of course there are critically important negatively charged elements (anions) as well. **Here are two key anions required to grow quality forage:**

Phosphorus: Phosphorus P_1 (readily available) should ideally be near 30 ppm, P_2 (reserve) should be 80 ppm on the soil test.

Sulfur: I would ideally like to see this near 25 ppm on your soil test *in a properly drained soil.* (Note that if you hit 50 ppm without sulfur application, it may be an indicator of a drainage/hardpan problem.)

We cannot forget the **trace elements**. Here are some important ones to consider along with their ideal soil test levels:

Boron: at least 2 ppm

Copper: 2 – 5 ppm

Manganese: 20 ppm (Ideally in a 1:1 ratio with iron. Some consider this to be an indicator of soil health / good biological activity.)

Zinc: 5 ppm or more (up to 10 ppm), especially if soils are very high in reserve phosphorus.

That ends a few points regarding *chemical* balance, but there is still more to the story - both the physical and biological aspects of the soil must be considered:

Physical
* Good drainage?
* Structure - compacted & tight or loose & crumbly?

Biological
- Is there evidence of a good earthworm population?
- Is organic matter being recycled properly?
- How does the soil smell - a rotten septic odor from anaerobic conditions or does it have a normal "earthy-root cellar odor" as from well "ventilated" soil?

Much, much more could be written on these aspects of the soil. **It is critically important that it be recognized that the availability and usefulness of the *chemical* portion of the soil is dependent upon the *physical* and *biological* aspects.** *A balanced, healthy soil is one in which all aspects (physical, chemical, biological) are operating at optimum levels in harmony with one another.* Soil is not just "dirt" it is a live organism. Check it's "pulse" on occasion.

The following article gleaned from the Missouri Ruralist will add to the above thoughts The author does a tremendous job of approaching the subject matter and provides some *independent confirmation* of the value of improving chem-phys-biological management practices -in the case that you need something other than *"Tom says."* (It is directed more toward cash crop farmers than dairymen, but you will get the point.) Emphasis added.:

by Dan Crummett, Missouri Ruralist, Mid-February 1997

Life in the Soil: A Neglected Frontier
Some soil microbes could be "ace-in-the-hole" in drought years

The early morning winter sun left long shadows as Og ambled out to the hay stack, wooden rake in hand, to fetch a ration for the master's cow.

Og knew good grass in the summer made cows fat, and hay in the winter kept cows alive. Cows ate grass and hay and they fattened and survived. To Og, who never thought much about cause-and-effect as he lived out his medieval life as a serf, it was simple: grass and hay eaten by the cow equaled beef and milk.

The idea that the cow wasn't really digesting all that grass and hay herself never occurred to Og or his friend, the hunchback bell ringer in the village. That would come years later, after someone "invented" the rumen filled with "bugs" that did the actual digesting for the cow. Had they known about the rumen and its bacteria, Og and his friends might have improved the growth rate of the king's cattle by changing their diet - thereby winning many blue ribbons at the annual Fiefdom Free Fair and Jousting Contest.

Og aside, the discovery of ruminant microflora and their ability to synthesize protein from urea revolutionized food production and animal husbandry. The health of the rumen quickly became recognized as the key to the health, well-being and profitability of the animal.

One can't help but wonder if modern agriculture isn't following in Og's footsteps in its traditional approach to soil quality and microbiology - and the common neglect of soil microbiology in favor of irrigation and applications of N, P, and K.

* * *

J. Q. Lynd, professor emeritus of soil microbiology at Oklahoma State University, isn't one to get into a political battle over what has become "traditional" agriculture. And, he has no quarrel with those who note that "farm products are sold by the bushel, not by the relative 'health' of the soil on which they are grown."

Still, Lynd says in years like this one, when drought ravages traditional agricultural plans, enterprises based on farms with healthy soil microbes may be far better off than those whose operators never considered soil to be anymore than an anchor for plants.

> "As long as we apply nutrients and supply irrigation water, there hasn't been a great deal of cause to consider the soil microbiology," Lynd agrees. "But, when plant stress, or an economy that makes purchasing inputs difficult are factors, the life forms in the soil can make a significant difference."

Lynd, whose internationally-known career has spanned 50 years working with soil microflora, the antibiotics they produce, and their place in soil building and plant growth, says there are millions of microbes in a gram of soil and tens of thousands of species.

> "The eternal life and death cycle for all creatures is tied up in the soil microbiology. The soil itself is a product of the activity of microbes living and reproducing."

As an example, Lynd points out a commonly-seen patch of lichen on a sand stone rock.

> "A lichen is a population of mycorrhizae, a natural fungi-algae combination, that has attached itself to the rock in the presence of algae. The algae uses the fungi as an anchor and shelter, and the fungi uses the food produced by the photosynthetic algae. Their presence on the sand stone, anchored by the fungi's root-like structures (mycelium) soon begins to dislodge pieces of sand - until a dust-like substance is found in and around the lichen. Soon, liverworts and mosses begin to populate the lichen's area, further degrading the sand stone and adding - ever so slowly - to the arable soil of the earth,' he explains.

Lynd says fertilizer and herbicide use are both dependent upon soil microbiology, because both commercial fertilizer and herbicides require soil microbes to function properly. Also, it is soil microbial action that degrades pesticides after their control action has been accomplished. In fact, with no exception, all of today's antibiotics for human health are obtained from common soil microorganisms.

Back to basics. Forty years ago, the USDA's *Yearbook of Agriculture, SOIL,* 1957, outlined the three major soil microbes on which agriculture depends.

1. Bacteria, the smallest and most numerous of free-living organisms in the soil. Despite their size, however, their total weight in the top foot of an acre of soil can approach 2,000 lbs.

Most bacteria derive their energy and cell carbon from organic matter in the soil - that stored by other microbes or plants. A few have pigments necessary for the trapping of light energy and photosynthesis, thus allowing them to obtain their energy from the CO_2 in the atmosphere.

The nitrogen-fixing bacteria, *Rhizobia*, probably are the best known of these organisms.

2. Soil fungi. These microscopic parasitic structures are important allies to a plant under stress because of their spider-web-like rooting structures. Containing cell walls of chitin, the same material as an insect's exoskeleton or an armadillo's shell, mycelium of various mold-like fungi actually form transport tubes in the vicinity of a plant's root hairs, says Lynd.

"In times of drought stress, this structure obtains soil moisture and intercepts phosphorus (which is immobile in the soil) and other trace elements needed by the plant. It forms a secondary root system just as the plant needs it," he added. "Under irrigation and high levels of plant nutrient input, such formations are less pronounced in the root system. Still, the micorrhizae are there in so-called 'healthy' soils, waiting for that stress period."

3. Algae. "Most people can remember seeing a green or blue green substance on the surface of the soil after a rain. Blue green algae are responsible for that color," Lynd explained. "During drought periods - even in the desert - these organisms lie quiescent on the surface. Once water is available, as soon as sunlight is present they begin photosynthesis, and at the same time they begin fixing nitrogen.

Algae range from unicellular and microscopic types to the easily visible fleshy and filamentous types. Those that live beneath the soil surface - out of the light - must do so by using stored carbon of the soil or plant matter as does fungi.

As recently as 1995, the *Journal of Soil and Water Conservation*, in an article by A. C. Kennedy and R. I. Papendick, USDA-ARS researchers, stated the following:

> "Microorganisms can alter nutrient solubility making otherwise unavailable nutrients available to the plant.
>
> "N_2 fixing bacteria form nodules on plants roots and transform N_2 gas to plant-available nitrogen.
>
> "Micorrhizae are usually nonpathogenic and form symbiotic associations with plant roots (to absorb soil moisture for the plant in dry periods).
>
> "Microbes also play a major role in the formation of good soil structure. Bacterial mucigel and hyphal threads produced by fungi and actinomycetes bind the soil particles together. Microbial activity helps to aggregate the soil, which reduces erosion, allows for good water infiltration and maintains adequate aeration of the soil."

Care and feeding of microorganisms. All that sounds like just what all farmers would want: Nitrogen fixation, nutrient-seeking structures surrounding roots, improvement of soil structure, reductions in soil erosion, improvements in water infiltration and aeration rates.

So, how does one go about making life easier for these neglected workhorses?

> Lynd says anything a grower can do to improve the soil's organic matter will help.
>
> "All of these microbes in some way or another rely on organic carbon in the soil. And, the best way to improve organic matter is to keep something actively growing on soils.
>
> "Legumes are always good tools to help boost the productivity of soils, but there's probably been too much emphasis placed on plowing under green manure crops," Lynd explains. "The roots themselves are the key to building carbon contents of the soil. Keeping an active root system is very important. That's why we in the Southern Plains are so fortunate to have the option of growing winter wheat. It keeps the soil covered during the winter and continually fixes carbon in the soil with a fibrous root system."

Other ideas include any kind of reduced tillage.

> "The best way to make carbon available to microbes is to open it up to the presence of oxygen," Lynd explained. "That's why plowing the prairie soils used to result in such spectacular plant growth responses. Carbon and nitrogen fixed in those soils over eons was made immediately available as the plow "opened up the damper' on the oxidation process. It's just like a stove: open the damper and the hotter the fire burns."

So, the less tillage one uses, the more opportunity microbes have to begin immobilizing and storing carbon for later use.

> "People always talk about humus as a positive soil structure, and many times don't realize it is a quantifiable product," Lynd noted. "Humus is a soil containing about 10 parts carbon to one part nitrogen (by weight). Humus is the "goal" of various soil microbes," he added. "If all higher forms of life ended on Earth immediately, and soil microbiology continued, ultimately the Earth's surface would be stabilized in humus."
>
> To take advantage of this naturally-occurring process. Lynd says growers have to ensure there is no physical movement or loss of the soil through good production practices, and to improve the soil's productivity by improving its organic matter content.

Think back to the illustration of Og for a moment. Once ruminant microflora were understood, the knowledge unlocked tremendous advances in animal husbandry. Couldn't the same be true of the bacteria, fungi and algae in the soil?

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I'll add an excerpt from an article produced by Pro Farmer Magazine as well (emphasis added). Again, although it is directed more toward cash crop farmers (looking at yield *only*), I think you will recognize the confirmation of the **DNFTSU** approach to success and how this may apply to your farm.

> Last week, we heard solid scientific verification of soil yield concepts which visionary leaders have presented at our "Renewable Farming" seminars for almost 10 years.
>
> We've maintained that consistent high yields of quality crops depend much more on the *biological* dynamics of soil than on chemical fertility alone.
>
> We've argued that three crucial facets of "fertility" are not N, P and K, but instead are these aspects:
>
> 1. **Biologically-active humus**, the goal of "organic matter" buildup.
>
> 2. Your soil's ability absorb water while remaining porous enough to exchange gases such as oxygen and carbon dioxide. "**Tilth**" is a good label for this aspect of soils.
>
> 3. **Calcium and pH level**, especially the soil's **calcium/magnesium ratio**.
>
> A few farmers, perhaps two or three thousand, perceived enough evidence to begin building their soils this way.

Meanwhile, major corporations began pushing "precision farming" with global positioning systems (GPS) and grid soil testing of NPK fertility. This view says you can "fix" soils with variable-rate application of NPK, if you just know *where* the analysis is off. Is this working?

> "*We can't find anything farther from the truth*," one of the nation's top GPS specialists told us Wednesday. Don Larson, president of Larson Systems Inc., Ames, Iowa, has worked closely with GPS technology with real farms and real farmers for years. He reports:

"We could not show any linkage between fertility levels and crop production levels on a site-specific basis. If anything, the highest yields tend to come on the areas testing the lowest in standard soil analysis."

Larson goes on to say, "**Three factors show a correlation between soils and yield:**

1. **"Organic matter. Not necessarily the amount, but its biological activity.**

2. **Water holding capacity and the proper amount of moisture.**

3. **Calcium levels and pH.**

"If you don't have those three parameters, you won't raise top yields. These are the only three issues where we've found a correlation between computerized soil maps and field maps from GPS yield monitors. You cannot find the correlation with conventional fertility."

* * *

If you would like *a little more* third party independent confirmation, how about another good article from the December 1996 issue of The Furrow by Rex Gogerty, entitled "The Dirt Doctor" (emphasis added).

*Over the past 15 years. **Terry Schneider's** soil-care program has reduced annual erosion on his highly erodible soils from 25 tons to as little as one ton per acre. On some of his level land, he's actually building topsoil. Meanwhile, he also has improved the structure and water-holding capacity of his soils.

Schneider, who farms near Shirley, Ill., attributes much of the improvement to reduced tillage, terraces, and better residue management.
"My long-term goal," he says, "is to return much of the organic matter and the chemical and biological activity, to these prairie soils."

For assessing the internal status of his soils, Schneider digs a 4-foot deep observation pit each year in a representative field.

"With cross-section views, I've been able to see the effects of soil microbial activity and a reduction of soil compaction over the past few years," Schneider says. "The pits are handy for making quick examinations. It's easy to collect a sample of subsoil if you want to check its texture or water-holding capacity."

Root watch. Digging observation pits also allows him to determine whether soybean roots are fully nodulated, and whether corn roots are bright and vigorous.

Based on soil-pit and other observations, Schneider expects healthy corn and soybean roots to penetrate to depths of 7 feet in soils with average bulk density and good microbial activity.

A USDA study conducted on his farm two years ago confirms that his soils provide a favorable environment for vigorous root growth. Scientists inserted walnut-size TV cameras into transparent tubes placed in the soil. The underground eyes tracked roots from Schneider's corn penetrating to a depth of 4 feet when plants were only 3 feet tall. The scientists attributed much of the rapid growth to high fertility, little compaction, and excellent microbial activity.

By switching to no-till, Schneider has reduced wheel traffic on his soils and made compaction less likely. In most cases, he deep ripped fields before starting to no-till them. Then, to help keep from causing new compaction problems, he avoids early planting on moist soils and heavy axle loads at harvest.

"Most soils have excellent healing power if you provide enough care and patience," he says. "Freezing, thawing, and drying undo *some* compaction over the years. Vigorous root systems also break up compacted soils. Deep tillage can help shatter shallow compaction, and staying off the land when it's wet helps prevent new compaction problems."

Schneider says earthworm activity in his soils is increasing. He describes such activity as a good indicator of a healthy soil. He notes that in addition to aerating the soil, earthworms transport nutrients, and their burrowing improves water movement. In addition, by feeding on dead plant material, worms accelerate the breakdown of crop residues.

"From a soil-profile pit, it's easy to see networks of earthworm burrows," he says. "The tunneling is bound to improve the circulation in the soil."

Schneider farms with his wife, Joyce, and his daughter and son-in-law Connie and Matt Hughes. In addition to conventional corn and soybeans, they grow seed corn, white corn, and food-grade soybeans. They rotate the corn and beans. Schneider says the different root structures of the two crops, and the abundant crop residues produced by the rotation, help improve soil structure and reduce erosion.

Fertility program. Schneider gains additional information about his soils by having samples tested before he fertilizes. He spoon-feeds nitrogen to corn to reduce the risk of over application and leaching. In the fall, when his fields are usually dry, he injects 28% liquid nitrogen. He injects additional liquid N with his planter, and injects more later in a sidedress application. He bases his application rates and timing on yield goals of 175 bushels per acre for corn and 50 bushels for beans.

With good soil structure, Schneider says, plants can take greater advantage of nutrients and organic matter in the soil. Favorable soil structure also reduces surface crusting and eases plant-root penetration.

"What we're looking for is good tilth," he says. "The physical condition of soil and the size of particles in the top 10 inches are really important. Friable, clod-free soil soaks up moisture and decomposes organic matter for better plant growth and less soil erosion.

"I've developed a greater and greater respect for dirt over the past few years," Schneider adds. "As our program has shown, **it will respond well to a comprehensive care program.**"

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Still haven't had enough?! Read the following article from the February 1994 issue of Farmer to Farmer magazine. (Emphasis and [notes] added.)

by Lori Pottinger

Beyond N-P-K
Making your soil biologically active

Farmers fertilize - it's part of the job description. But evidence is growing that it's better in the long run to feed the soil, and let the soil feed the plants.

In other words, by concentrating on feeding the soil's many microscopic life forms, you'll spend less time and money adding expensive chemical fertilizers, and possibly reduce the need for other chemical inputs as well.

Treating your soil as a living organism is the first step toward reducing the need for chemicals. "The soil is a living thing we are very much dependent on, but we just treat it like dirt," says farmer Dennis Sanne. Like any healthy farm animal, a "living soil" takes a little care, but it pulls its own weight.

The key ingredient to a living soil is organic matter, and the most complete and readily usable form of organic matter is compost. Compost is as much a process as a product, but generally refers to a wide range of partly decayed organic matter used to amend soil.

The Soil is Alive . . .
The more types of microorganisms in your soil, the better. Microorganisms are the soil's digestive system, helping decompose organic matter quickly and efficiently, and unlocking minerals so plants can use them. When the microorganisms are done eating, the soil is a cornucopia of nutrients for plants.

"Managing your soil microbes is like managing livestock," says Ralph Jurgens of New Era Farm Service, a Central Valley firm that produces compost. "You have to feed them, house them, make sure they have sufficient air - everything they need to thrive." There are hundreds of species of soil microorganisms, numbering up to a billion microbes per gram of soil. The most important to the farmer are the following:

Actinomycetes are key to the formation of humus, and are responsible for the earthy smell in compost or good soil. Found three to four inches below the surface, their digestive process helps free up the soil's carbon and nitrogen, which can then be used by plants. They also produce antibiotic substances which inhibit undesirable bacteria, and stimulate beneficial ones.

Bacteria are the primary decomposers of all organic matter, and utilize carbon, nitrogen, sulfur and iron as food. "Some of the most important bacteria are the ones which convert unavailable nitrogen in the soil's organic matter to ammonia and those which convert ammonia to nitrites and then to nitrates," according to The Complete Book of Composting. These bacteria are also some of the most sensitive to chemical inputs. Fungicides and fumigants applied to soil can greatly reduce their activity.

Fungi break down cellulose in compost, and like bacteria are initial organic matter decomposers. They decompose crop residues, increase soil aggregation, and increase the availability of plant nutrients. Numerous studies have proven that certain fungi can also trap and feed on nematodes. While there are some fungi that prey on plants, they are a minority. "The majority of fungi are beneficial, and are absolutely necessary for breaking down organic matter," says soil scientist Robert Parnes and author of the book, Fertile Soil. Obviously, *fungicides kill both good and bad fungi indiscriminately.*

"Compost stimulates soil microbial activity and diversity," says Mark Van Horn, director of the Student Experimental Farm at UC Davis. Giving your soil regular doses of compost will greatly increase the numbers of beneficial microorganisms in your soil, *as long as other conditions such as temperature, moisture, pH and aeration are favorable.* [I would normally recommend *sheet composting* by applying light coats of manure to crop residue. –T.W.]

Farmers may soon be able to keep track of their soil microbes with a simple home test kit like the ones developed for medical conditions and home pregnancy testing. "We're developing a diagnostic tool now so that farmers can measure the soil life in their fields," said Will Brinton, president of Woods End Research Laboratory in Maine. The kit should be available very soon, and will be "inexpensive," according to Brinton.

Killer Compost

Many microorganisms have killer instincts. When their populations are in balance, *they can keep plant pathogens and soil-borne diseases in check, kill harmful nematodes and bacteria, and generally wreak havoc on organisms harmful to crops.*

Although "compost science" is still in its infancy, there is already an impressive body of work documenting the ability of microorganisms found in compost to *protect plants from pests.* Here are examples of recent research.

The need to use methl bromide to fumigate potting soil was shown to be *unnecessary* by a study at the Ohio Agricultural Research and Development Center of Ohio State University. A particular blend of compost used in potting mixes all but eliminates diseases caused by three deadly microbes: Phytophtera, Pythium and Fusarium. This breakthrough led to the first patent ever for a compost, now produced by Ball Seed Co. in Chicago under the name Naturally Suppressive*. The New York Times reported that growers who had regularly lost 25-75% of their crop to soil-borne diseases lost only 1% with the compost mix, without using a fumigant or follow-up fungicide.

"Clover tiredness" in alfalfa was all but eliminated after four years of compost applications in Pennsylvania, reports Will Brinton. "We doubled the thickness of the stands," he said. The compost also reduced the need for herbicides because the crop showed such increased vigor that it crowded out the weeds.
Other pathogens that have been suppressed by compost include root knot nematodes, bacterial leaf spot, Phytophthora rot in soybeans, nematodes, Vreticillium in strawberries, potato scab, and others. "The greater the microbial diversity, the greater the diversity of pathogens suppressed," says plant pathologist Dr. Harry Hoitink in the New York Times.

Organic Matter and Soil Structure

You can't turn clay into sand, but you can change a soil's structure. Good structure or tilth increases the soil's drainage capabilities in heavy soils and the water retaining abilities of light soils, and facilitates the movement of roots. "A good argument could be made that the most important agricultural benefit of organic residues is their effect on soil structure. There is no practical way to produce a stable soil structure without organic residues," says soil scientist Parnes.

"Structure affects fertility indirectly *but substantially*, by facilitating the movement of roots through the soil. An improved root system enables a plant to more easily find nutrients," says Parnes. Adding compost is one way to introduce organic matter to the soil quickly, and can be done in any season. Cover crops are another, more long-term way to provide organic matter to the soil; the crop's roots will further improve soil structure. [A standard **DNFTSU** soil management recommendation!]

Compost vs. Fresh Manure

Fresh manure can be an important source of nitrogen, and also adds organic matter to the soil. But it is not as complete a product as compost, and must be used judiciously and handled more carefully. Manure's drawbacks include the following:

1. It may contain weed seeds, nematodes or animal pathogens.

2. It has a long break-down period, tying up water and nutrients in the process.

3. Unless properly handled, it is very susceptible to nitrogen loss.

4. It is very acidic, and may interfere with plant growth.

5. Because it is soluble, it can add nitrates to the groundwater.

Raw animal manures are high in salts.

Fresh manure varies considerably in nutrient content, depending on the type of animal, the nutrient value of the feed, and the age of the animal (older animals produce higher quality manure).

Fresh manure loses much of its nitrogen through oxidation. Experiments have shown that when manure is left on the surface, up to 25% of its nitrogen can be lost within the first 12 hours, and up to 50% within seven days. These losses can be essentially eliminated if the manure is incorporated into the soil immediately after application, or if it is composted. Many growers, however, have had success using partially composted chicken manures as a regular part of their fertilization program. Manures, partially composted or raw manures must be applied in the fall for a spring crop [standard **DNFTSU** manure management recommendation –T.W.] or in the spring for a fall crop to allow for decomposition in the soil.

Synthetic Fertilizers vs. Compost

With *synthetic fertilizers*, you can have too much of a good thing. Studies have shown that a steady diet of synthetics can *alter the ecosystem of your soil,* resulting in the need for increasing amounts of chemical fertilizers and pesticides. "It's a syndrome, and eventually the whole system goes downhill," said Brinton of Woods End Lab. [Long time point of argument that some soil scientists have held for the need to implement sustainable practices.]

For example, the vigorous plant growth stimulated by high quantities of nutrients, *especially nitrogen,* can deplete the soil of other minerals, according to Parnes. And the microbes that normally work to break down various soil nutrients will stop working when those nutrients are already in high concentrations.

Part of the problem with synthetic fertilizers is their reliance on the get-rich-quick effects of the three major nutrients, as well as their lack of micronutrients and their potentially harmful effects on beneficial soil life. While high-rate fertilizers do produce high yields, potential increases can be offset by losses from soil-borne diseases - problems that are greatly reduced in soils with high levels of organic matter and healthy populations of microorganisms. In cotton, for example, high rates of nitrogen can contribute to fungus, plant disease, and growth control problems.

A larger problem is the increasing nitrogen contamination of groundwater, a direct effect of the overuse of synthetic fertilizers. "Nitrogen fertilizers are so concentrated that *it's very easy to over-apply them*," says Parnes. *"It's very common problem."* [Especially on dairy farms!]

Though low in nitrogen, phosphorus, and potash compared to chemical fertilizers, compost produces tremendous growth responses in plants. A soil rich in microorganisms and organic matter is basically well-balanced. Studies have shown that compost substantially cuts the need for additional fertilizers, while still producing the same yields. Possible reasons include the anti-leaching characteristics of compost, the slow-release nature of its nutrients, and the optimum combination of macro and micro-nutrients. [In order to compliment a healthy soil system the need for balance of soluble/slow release and trace elements should be part of the design of a *quality* fertilizer product.]

"No one knows why, but the net effect of compost is always more than its replacement value - the equations never come out," said Brinton. "It's apparently greater than the sum of its parts."

The math may be difficult to prove, but it's clear that making the soil work for you is smart farming. A living soil is a long-term investment, but for farmers the equation adds up to a healthier farm. [Note that *farm management* will never be reduced to a simple mathematical equation!]

* * *

Finally, I'll end with this excerpt from an article by John Russnogle in the February 1997 issue of Soybean Digest, the quote is from Paul Gordon, a crop consultant in Bentonville, IN (emphasis added). Paul notes a *chemical* imbalance that has *physical* and *biological* implications.

You can eliminate a lot of your wet-field problems by paying closer attention to your soil tests, according to Gordon.

"Spring after spring, I see farmers fighting fields with standing water, and they think it's compaction," he says. "In many cases, it is **excessive magnesium.** Anytime your base saturation of soil magnesium exceeds 25% on your soil test, your soils will tend to seal when it rains.

"In some fields you can see water pond right over a tile line. Clay-based soils with a high CEC (cation exchange capacity) particularly on slopes, are most prone to the problem. There's no quick fix, but there are ways you can reduce magnesium content of the soils."

* * *

So, as you have read, I am not alone in this phys-chem-biological balance thinking! Isn't this just good common sense?! I simply wanted to expose the reader to third party confirmation of the need / benefits to taking better care of the ground they grow, especially their forage crops on. There, now that we have established that you must *care for your soil as you care for your livestock*, let us move on. ☺

I'm accustomed to talking about N,P, & K when discussing fertilizer needs, but when you bring up calcium, sulfur and other trace elements it sounds more like feed programming than fertilizer. This is confusing, aren't more consultants promoting these extras?

You are exactly right. It does sound like feed programming ***because that is exactly what it is.*** This is basic to the **DNFTSU** approach to meeting the nutritional needs of your cows. What is confusing to me is how the majority of soil work in farming today continues to be done without regard to elements other than N-P-K*, while at the same time the dairy farmer is sold more and more supplements* to make up for the resulting deficiencies. If you as a dairyman take the time to investigate some of the advertisements for popular trace element supplements, you will find that part of the promotion cites needs for the product due to "modern fertilization practices" that have resulted in lowered levels of trace elements in forages. An advertisement put out by one major company even boasts that their quality *equals that which would be found in homegrown forages* due to the fact that it is in organic (chelated) form. Many of these advertisements quote university researchers to support their claims, but more on the traces later. Other major elements such as <u>calcium and sulfur</u> are vitally important as well and must be kept in balance with potassium and nitrogen to optimize digestible energy and protein quality in forage. Why are these *essentials* ignored???

To answer the question of are so few consultants promoting these ideas?" I believe **this is due to the fact that most consultants never complete the connection between soil, forage, and dairy nutrition.** Large companies may do both soil consulting and dairy nutrition consulting, but the right hand doesn't know what the left had is doing (and normally doesn't care). Additionally, university research does not *normally* study ***systems*** (one *system* of farming vs. another *system* of farming). They have a "tunnel vision" approach taking one variable a time -as this fits their definition of research (but still makes no "connection"). However, I am certain I can pursuade you that the *systematic* approach of **DNFTSU** is the most *logical* approach to Dairy nutrition and that it is more economical to *grow* your feed instead of *buy* it. The key is in changing your farming *system* **-** not simply adding some new product. The system approach works!

Now let us list some of the benefits of these rarely mentioned elements in most modern soil fertility programs:

Calcium's benefits:

- It is necessary to build digestible fiber (a high level of *digestible energy*) in the forage plant (needed for cell walls and growth of roots, stems, leaves and seeds).

- It facilitates greater uptake of other minerals into the plant and is required to manufacture quality plant proteins.

- It increases plant disease resistance.
- It improves soil structure giving better aeration, water uptake and root growth.

- It stimulates beneficial soil organisms (earthworms, bacteria, fungi).

- It is needed by animals and humans for bones, teeth, muscle, heart, blood clotting and nerves.

- It is an important component of milk.

For an "independent" *university* opinion on the benefits/need of calcium please note the following excerpt from the textbook "Our Soils and Their Management" ISBN 0-8134-2848-3 (emphasis added):

> On the average, approximately 3.5 percent of the earth's crust is composed of calcium, but since plants cannot move about as animals do, the calcium within reach of every growing plant must be adequate. When calcium is not adequate (and this is the case in most humid region soils) it is added to the soil, usually as ground limestone. ***The most productive soils in the world are abundantly supplied with calcium.***
>
> Calcium is found **in the middle layer of the cell walls in all green plants.** *There it acts as a guard to the cells, permitting only those nutrients that are listed in the "social register" to pass.*
>
> In addition to its direct use by plant cells, calcium, when added to an acid soil, **makes many other nutrients more available to the growing plant.** Three of the nutrients thus mobilized are phosphorus, nitrogen, and molybdenum. While these indirect effects are highly important, of almost equal importance is the fact that **lime stimulates all biological activity**, and this results in *greater soil granulation, better aeration, increased root growth,* and *higher yields.*Furthermore, calcium *hastens microbial breakdown of organic residues and thus releases some of all essential nutrients.*

Although the word "lime" and "calcium" are used interchangeably in the above paragraph, anyone can understand that **calcium is not merely a coincidental component of lime,** but rather *an essential nutrient to both soil microbes and plants.* In fact, from my school of thought a soil can be neutral in pH and yet still be deficient in calcium. An example would be a soil with a 6.8 pH and base saturation of 56% Ca, 38% Mg and 6% K. This soil would likely produce alfalfa with excess potassium and a low level of calcium and magnesium and in turn create health and productivity problems in the barn. This would be due to not only the excesses and deficiencies of the three major minerals mentioned but also due to the lower level of digestible energy (plant pectin / cellulose) that can be expected with excess potassium in relation to calcium / magnesium.

I am not alone in my view of the need for soil cation balance. Many dairy nutritionists are recognizing the problem that has been created with high potassium forages coming off of land abused with unbalanced fertility. The following is a quote from Jim Peck in the January 1997 issue of Dairy Today (emphasis added).

> Based on our experience with soils, crops and cows, we have developed several strategies to minimize the potassium problem:
>
> **Start by managing soil fertility.** Soil tests let you minimize soil potassium levels. Keep them low on grasses and moderate for other crops. The pH should be over 6.5 and **calcium should have a soil base saturation of at least 68%. Low soil-calcium levels will increase the potassium uptake by the plants.**

* * *

Stop and think for a moment. Just use a little common sense that you already know to be true when feeding cows: just as pH in the soil is important (the plant's stomach) so it is important in the cow's rumen for health and productivity; and **just as mineral balance is important in the cow's stomach so is it important in the plant's stomach - the soil!** Both pH and balance are important!

Sulfur's benefits: Soil sulfur in the available sulfate form is extremely important for at least three reasons:

Soil **-** vitally important in building soil humus and making nitrogen useful to the plant.

Soil organic matter is on a delicate balance that can be changed by many factors. The balance between nitrogen and sulfur in the soil system is critical as to how much humus is retained in a soil. Soil microbes will keep decomposing organic matter (crop residues, manures) until the N-S ratio is approximately 6 or 7:1. Another ratio of importance is the C-N ratio, which is approximately 10 or 11:1 in stable organic matter (humus), since humus is about 60% carbon.

Translating these ratios into something meaningful indicates that for every one pound of sulfur available for soil microbes to use, the soil will be able to retain a little over one hundred pounds of humus. *Without* that pound of sulfur, that one hundred pounds of humus will be decomposed by microbes and lost to the air as gases. *With* adequate sulfur the most valuable component of the soil can be maximized - humus.

> Here is how it works:
> - 1 pound of S complexes with 6–7 pounds of N
> - 6–7 pounds of N complexes with 60–70 pounds of carbon
> - 60–70 pounds of carbon complexes to form 100–125 pounds of HUMUS

Crop residues normally contain only 0.05 to 0.15% sulfur, or 1–3 pounds of sulfur per ton, only enough to save five to 15 percent of the residue as humus.

The best way to ensure that you maximize soil humus content is to apply a sulfur source. Use a sulfate material for best immediate plant availability. Elemental sulfur can be too acidic for some conditions and must go through biological conversion to sulfate to become available. (However, sulfur in the elemental form [the yellow stuff] can be the appropriate choice when dealing with high pH soils that have a high percent base saturation of calcium [75% plus] and therefore would not benefit as much from the soluble calcium from gypsum - *but would benefit from the acidifying effect of elemental sulfur.*)

Now, **regarding feeding the plant**: research has found that if the carbon-to-sulfur ratio in organic residues is above 50:1 (high carbon, low sulfur), most of the sulfur they contain will be immobilized in microbial cells, while below a 50:1 C-S ratio (lower C, higher S) the sulfur will be mineralized (transformed into plant-available sulfate). This available sulfur can then be used to grow a healthy forage plant.

Forage / animal **-** high quality **protein** cannot be manufactured by the plant and rumen microbe of the cow unless sulfur is available for the formation of methionine.

Methionine is generally recognized as the primary limiting amino acid (building block of protein) in dairy nutrition. Two other important sulfur amino acids are cystine and cysteine. Inorganic (rock) sulfur added to rations is not nearly as effective as organic sulfur (methionine, etc.) in maintaining health and productivity. Plants that are deficient in sulfur are deficient in quality protein and may tend to have higher levels of non-protein nitrogen/nitrate which can be very damaging to animal health.

Forage / animal **-** research has shown that **forage fiber digestibility is improved significantly by sulfur fertilization.**

This means *more digestible* ***energy*** which is nearly always a limiting factor in dairy rations. A number of papers written by researchers such as Spears, Buttrey, Chestnut, and others were published in the Journal of Dairy Science and Journal of Animal Science back in the mid 1980's. Their research trials dealt primarily with the effects of sulfur (sulfate) fertilization on digestion and performance of animals fed the resulting crops.

Here are some key points of interest found in the research:

- Yield could be improved only where soils were deficient in sulfur.

- **Digestibility of fiber fractions, especially lignin, improved when sulfate was applied to the soil. This occurred even if the soil was not "deficient" in sulfur.**

- Increases in crop sulfur levels were shown to be mainly inorganic sulfur, such as sulfate, in some crops. In other crops, a large portion of the extra sulfur taken up by the crop was organic, that is **sulfur containing amino acids**, protein and fiber fractions.

Interestingly, even if the crop took up extra sulfur in the inorganic sulfate form, animals performed better on those crops than if the sulfate was added to the ration in the form of a mineral supplement.

Therefore, **nutrition *must* begin in the soil *if our definition of quality is defined by the livestock!***

* * *

The following is an article from The High Plains Journal, November 3,1997 that brings additional independent, third party confirmation (emphasis added):

Fertilizers Supplying Nitrogen and Sulfur Increase Gains

In ongoing field trials at the Shenandoah Valley Agricultural Research and Extension Center in Steeles Tavern, VA, fertilizing tall fescue with nitrogen and **sulfur**, in the from of ammonium sulfate (21-0-0-24S) fertilizer, increased average daily calf gains by 15%, compared to treating fescue with nitrogen fertilizers that do not supply any sulfur.

“The total weight gain advantage for forage treated with ammonium sulfate amounted to roughly 55 pounds per calf over a seven month period,” reports Dr. Joe Fontenot, Virginia Tech professor of animal science and coordinator of the study. “At current stocker beef cattle prices of appropriately 80 cents per pound, the additional gain from sulfur fertilization is worth about $44 per calf.”

These weight gains have been consistent over a two year period and are supported by earlier metabolism trials with sheep, conducted by Dr. Vivien Allen, formerly at Virginia Tech, and Dr. Fontenot. Animals fed corn silage fertilized with ammonium sulfate used dietary nitrogen more effectively than animals fed corn silage fertilized with nitrogen only.

They also compared sulfur fertilization to direct feed supplementation with sodium sulfate and found that the animals used dietary nitrogen more effectively when the sulfur was suppled through fertilization. Similar results also have been found on orchardgrass and sorghum silages by these scientists.

In the beef cattle study, tall fescue pastures were fertilized in April and May. Half the fields were treated with ammonium sulfate to supply 69 pounds of sulfur per acre. The other half of the fields were fertilized with nitrogen only. Fontenot indicates that weight gains may be due to improved dry matter digestibility and nitrogen utilization, when forage is fertilized with sulfur.

In 1995, sulfur fertilization generated a weight gain increase in suckling calves of 0.3 a pound per day from March to October. In 1996, the increase in gain was about 0.3 pound per day, over the same time period. This represents a 15% increase in gain over calves grazing on tall fescue that was fertilized with nitrogen only.

According to Mark Alley, Virginia Tech soil fertility specialist, these weight gains were generated on silt loam and clay loam soil types *that have naturally high levels of sulfur.* “If we did a yield study here, we probably would not see any yield increase from sulfur fertilization,” says Alley. This indicates that the animal weight gains were probably due to an **increase in forage quality**, rather than quantity. And it means that livestock producers may benefit from sulfur fertilization of forages even where soil tests read medium or high.

* * *

Finally, you can read the following brief comments by Frank Lessiter, Editor/Publisher of Farmer’s Digest (Vol.60, No. 9, March 1997) Emphasis added.

Cleaner Air Could Be a Mixed Blessing

While everyone favors reducing air pollution, it could sharply reduce the supply of sulfur provided to crops, trimming yields and reducing returns.

In many areas, crops have received sulphur, an important plant nutrient, in the form of sulphur dioxide, which is a by-product of industrial emissions.

Yet these "pennies from heaven" may be drying up, reports George Rehm, agronomist at the University of Minnesota. Airborne sulphur usually reaches soils through rain or snow, and the amount supplied annually from air has varied from 5 pounds in rural areas to over 30 pounds in areas downwind from heavy industry.

Rehm says many fertilizers used to contain sulphur, but most of today's popular high-analysis types do not. Soils low in organic matter are also more likely to become sulphur deficient.
Rehm says the implications are clear. With cleaner air, farmers will have to take a closer look at sulphur needs.

* * *

To complete these comments on the benefits/need of sulfur in soil fertility programs, I would like to include the following excerpts from an Iowa State University Extension service bulletin titled "Sulfur - An Essential Nutrient." It was prepared in 1983 by Extension Agronomist Randy Killorn. (Emphasis added.)

> . . . Sulfur is an essential component of several amino acids, the building blocks of proteins. Over 90 percent of the S in plants is in the amino acids cysteine, cystine, and methionine. Plants require adequate supplies of S for nitrogen (N) metabolism, since both S and N are required for protein synthesis.
>
> Sulfur is required for the activation of some enzymes. for example, nitrate reductase, which is involved in converting nitrates to amino acids in plants.
>
> Lack of adequate available S results in a decrease in soluble protein accompanied by an increase in nitrate in plants. These changes can be detected by chemical analysis of plant tissue. Several researchers have suggested that the ratio of total N to total S in plants be used as a diagnostic tool for determining S deficiencies. An N:S ratio of 15:1 has been suggested as a *critical value* for nonlegumes and a ratio of 11:1 for legumes. . .
>
> . . . Probably the best indicator of S deficiency is the total N:total S ratio in the plants. It is generally agreed that this ratio should be about 15:1 in healthy plants. High quality forage probably requires a total N:total S ratio of 10:1. If ratios are larger than these, S is required.

* * *

What do the trace elements do for me?

A general statement that could be made for the trace elements is that they are extremely important catalysts to metabolic processes within the plant and animal. As catalysts they could be compared to hammers, saws, and nails when building a barn. Although they are used in small amounts and may be needed only to do the work (not as components of the end product), they are vitally important to building and maintaining a healthy "barn".

To spark your interest in applying them to your soil, I want to quote the following newsclip from January 1999, *Country Today* farm newspaper by Casey Langan. Emphasis added.

Agronomist Stresses Role Of Micronutrients

> Micronutrients are essential to optimum crop production, according to Alan Blaylock, an agronomist for Agrium USA, based in Denver.
>
> Mr. Blaylock spoke at one of the more than 70 educational programs focusing on Midwest research held at the Wisconsin Fertilizer, Aglime and Pest Management Conference Jan. 19-21 at the Dane County Exposition Center, Madison.
>
> Mr. Blaylock said that while micronutrients may not be applied to crops as heavily as are nitrogen, phosphorus and potassium, they are just as essential.
>
> "In our modern high-yield cropping systems, micronutrients may be the source of the next yield increment," he said.
>
> Mr. Blaylock said that in many cases, adding micronutrient fertilizers to soils is not necessary. Micronutrient need is evaluated first by soil testing. Appropriate soil testing provides an indicator of the probability of crop response to a given nutrient. He said a high soil test means the probability of crop response. Soil pH level is a major determinant of micronutrient availability in the soil. Availability of born, copper, iron, manganese and zinc *decreases sharply as soil pH increases*, he said.
>
> Adverse soil conditions, cold temperatures, wet soils, poor drainage, compaction, root pruning and disease decrease rooting volume and therefore negatively affect the availability of nutrients, especially **zinc**, he said.
>
> Crops vary greatly in sensitivity to micronutrients. Mr. Blaylock said. Understanding a crop's specific nutrient requirements will help improve prediction of micronutrient needs and maximize economic benefits of the nutrient management program, he said.
>
> **Alfalfa** is considered most responsive to boron and copper; **corn** to copper, manganese and zinc; **oats** to manganese; and **soybeans** to iron, manganese and zinc, he said.
>
> Micronutrient source is another factor determining crop response, Mr. Blaylock said. Unlike many nitrogen, phosphorus and potassium fertilizers, there is much differentiation among available products. Micronutrient fertilizers must supply the nutrient in a form that is water soluble or becomes soluble in the soil. He said studies have found that products that do not meet minimum solubility requirements produce less than maximum crop response.

> "Confident diagnosis of micronutrient needs requires more than a scan of laboratory results from a zero to 6-inch soil sample. Agronomists are being irresponsible if they don't ask some questions," he said.
>
> He said success increases dramatically when considering overall fertility management, management level of the producer, soil type and conditions, crop sensitivity and past observations of crop response, <u>quality or deficiency symptoms</u>.
>
> The management conference, in its 38th year, featured a trade show with more than 100 exhibitors. The event was geared toward agribusiness professionals and educators seeking knowledge on soils, pests, crops, crop inputs and governmental regulations.

* * *

The above thoughts primarily focus on yield. Now turn your thoughts to *quality* for feeding livestock. Trace minerals do pay when soil and forage testing reveal low levels!

It should be noted that the trace elements that you receive when you start nutrition in the soil are *organic* (*chelated*) traces - which means that they are of the highest biological availability to your animals. It is becoming more popular (and necessary) to *sell* the farmer chelated trace elements in a bag, but he is rarely told of his ability to grow them.

Here are the benefits of the key trace elements that should be a standard part of your fertility program:

<u>Boron</u> - *essential* to make calcium available to *both* the plant and animal (not legal to supplement to the animal via the mineral bag - not cleared by the government as a feed supplement). (I don't want it to be - alfalfa is the best source!)

I would be remiss to neglect to note the connection between calcium and boron at this point so let me allow excerpts from literature provided by <u>the Potash and Phosphate Institute</u> and <u>Foundation for Agronomic Research</u> to make my point. Note that the boron-calcium interaction should not be forgotten and that the words boron and calcium should be placed together ("boron" should read "boron/calcium" for a better understanding). A study of the function(s) of calcium would lead one to the same general function(s) as boron. It is this understanding that **DNFTSU** recognizes as very important in your farms' soil/plant nutrition program. *Again note that calcium is not merely a coincidental component of lime,* but rather an essential plant nutrient. Boron *<u>and calcium</u>* are important! (Emphasis and [notes] added.)

> Seven decades have passed since scientists first demonstrated that boron is essential for plant growth. Since then, efforts have been under way to learn why such a small amount of boron has such <u>a large influence on **yield** and **quality** of crops.</u> [Study the calcium connection!]
>
> [Calcium/]Boron is an essential fertilizer element which becomes a plant food nutrient needed to efficiently convert sunlight, water, and air into high yields of quality food and fiber materials. Although <u>many functions of boron [/calcium] in plant growth are not fully understood</u>, a great deal is known. Some of the functions of this unique micronutrient in plant nutrition are very similar to its roles in animal nutrition.

[The Boron/Calcium Connection.]
***Cell wall structure** . . . Boron is involved along with **calcium** in cell wall structure. It is essential for movement of **calcium** into the plant and for normal **calcium** nutrition in plants and animals. There is a similarity between bone development in animals and cell wall development in plants.

***Sugar transport** . . . Photosynthesis transforms sunlight energy into plant energy products such as sugars. For this process to continue, the sugars must be moved away from the production line and stored or used to make other products. [Higher energy!] Boron [/calcium] speeds the flow of sugars produced by photosynthesis in mature plant leaves to new growing points and developing fruits. Boron [/calcium] is essential for providing sugars for root growth in all plants and normal development of root nodules in legumes such as alfalfa.

***Cell division** . . . [Calcium/]Boron is essential in the rapid growth areas of plants, such as root tips and in new leaf and bud development. This function is one involving the meristematic tissue in plants or the cells which are rapidly multiplying, allowing plant growth to occur. A shortage of boron [/calcium] is most often noted by a change in plant structure in these rapid growth areas. Boron [/calcium] ensures healthy plant storage tissue and conductive tissue for passage of water, plant products and nutrients to growing regions of the plant. [More digestible fiber!]

***Plant hormone regulation** . . . Plant hormones, like animal hormones, regulate many growth and reproduction functions. In plants, flower initiation, development of fruits, root elongation, cell walls and tissue formation are all influenced. Boron [/calcium] plays a role in regulating hormone levels in plants.

***Flowering and fruiting** . . . Boron [/calcium] increases the number of flowers produced, the retention of flowers, pollen germination, pollen tube growth, and seed and fruit development. [Calcium/] Boron shortage can, for example, cause incomplete pollination of corn or prevent maximum pod-set in soybeans.

Both plants and animals are healthiest and perform closer to their full potential when they are on a **balanced** nutrition program. Few would expect an athlete suffering from malnutrition to be a winner. In a similar manner, crop production will fall short of genetic potential when any of the essential elements are in short supply. This is as true for boron [/calcium] as it is for an element like nitrogen. The difference is that a shortfall of nitrogen is often much more visible.

* * *

Enough on boron, just remember that it is *calcium's little buddy!*

Copper - essential for enzyme systems in both the plant and animal. Alfalfa more consistently retains its lower leaves when copper is in abundant supply. Cows: necessary for strong hooves, immunity and the formation of hemoglobin in blood (for oxygen transport).

Manganese - assists in the formation of chlorophyll and is active in carbohydrate production in the plant. Accelerates seed germination. Affects the vitamin content of plants. Essential for normal reproduction in animals as well as the formation of normal cartilage, proper carbohydrate metabolism and function of the central nervous system.

<u>Zinc</u> **-** essential for formation of chlorophyll and plant growth hormones. Very important for protein and energy metabolism within the animal as it is used in more than 30 different enzyme systems in the cow. Zinc is also necessary in maintaining good immunity, healthy mucous membranes and aids the healing process of the animal.

To punctuate this mention of the importance of trace minerals, again, I remind you of the importance that the feed supplement industry as correctly placed on adding them to the dairy ration. The most convincing way I can do this is to quote two well known university researchers found in sales literature of a major chelated trace element manufacturer. The first quote comes from Mike Hutjens of the University of Illinois (emphasis added):

> Our level of trace minerals in feed may be *much lower than we expect* due to high-production agriculture, **crop fertility programs** and other factors that affect the <u>quality</u> of feed.

The second is from Jerry Spears, Professor of nutrition at North Carolina State University:

> Trace minerals that are *naturally present* in grass or corn are, for the most part, organic minerals. They're more like what's in [Brand X] than in the case of the inorganics.

Our University Nutritionists realize that our crops are low in mineral content due to fertilizer programming and that minerals in homegrown forage are far superior in bioavailability to the cow! *Homegrown* chelated minerals are also much less costly than manufactured ones!!

You say the success of the* DNFTSU *program is greatly due to your ability to improve forage quality. How do you define quality forage (there are differing opinions)?

Let's first define what quality forage is *not*:

- Just because a forage has been harvested at an early stage of growth does not automatically ensure that it is "quality." Although stage of maturity at harvest is important and no doubt is a contributing factor, this does not mean that it is *the only factor* (as is popular opinion).

- High protein on a feed test does not automatically indicate "quality." Although it is desirable to have near 20% crude protein on a forage test, we must keep in mind that <u>the test for "crude protein" is merely a measure of nitrogen</u> and without a *balance* of other key nutrients within a *healthy* plant that "protein" (nitrogen) is less useful and may even be detrimental.

- Low ADF and/or high relative feed value (30% ADF, 150 RFV+) on a feed test may give us an indicator of stage of harvest, but is certainly no exacting measure of fiber digestibility or true feeding value. The *assumptions* of these measurements/calculations have been proven incorrect time and time again by both farmers *and university researchers*. Again, although these may give us a clue as to quality, we should not use them as the final judges.

DNFTSU *definition of quality forage*

A highly digestible forage grown on a biologically active soil with balanced fertility that **can be fed at very high levels (ideally 70% of DM) to lactating dairy cows while maintaining high milk production** and adequate body condition without the need for excessive energy supplements and/or digestible fiber supplements and **with no need to be diluted with other forages in order to avoid metabolic/digestive upsets due an imbalance of nutrient therein.**

That was a very general and possibly confusing definition so let's break it down to this simple statement:

If you have habitually needed to feed less than 60% forage (DM basis), feed high levels of corn and purchase fat supplements, purchase digestible fiber supplements, or *dilute your forage in an attempt* to keep your cows milking and healthy you either need to re-evaluate your nutrition program and/or you simply do not have quality forage.

* * *

In order to properly assess the quality of a forage, we must view it from the same vantage points we use to assess a soil: <u>physical, chemical, and biological</u>. **The following are *universal truths* for all *quality* forages regardless of species.**

<u>Physical characteristics</u>: *Green* in color at feeding time and *soft textured*. Brown color and/or coarse or stemmy texture disqualify a forage from being categorized as *quality*.

<u>Chemical characteristics</u>: Reasonably balanced in the nutrients that ruminants require for optimum health and productivity. *Quality* forages cannot have such extreme nutrient imbalances that the *free choice* consumption thereof would create *malnutrition or harmful excesses*. The green color of quality forage is indicative of large amounts of chlorophyll, vitamins and protein amongst other valuable nutrients.

<u>Biological characteristics (as best judged by odor)</u>: *Quality* forage must possess an attractive aroma/sweet smell. *Musty* odors (indicative of mold), *sour/vinegar* odors (indicative of an improper acetic acid fermentation) *putrid* odors that hang onto your fingers (indicative of clostridial anaerobic "composting" organisms) or *tobacco* odors (indicative of heat damage) disqualify a forage from being classified as *quality*. Obviously *visual* signs of any of the above may confirm biological problems as well.

I will now be fair and give you a list of some of the *indicators* we in the **DNFTSU** school of thought use to judge quality *<u>alfalfa</u>*. These indicators are by no means the final judge (remember the cows?), but are another guide. (These *<u>do</u>* take into consideration the differences in variety of seed.) The focus on alfalfa is not meant to suggest that other forage blends such as peas/triticale or a grass/clover grazing paddock cannot support high production. These alternative forage species/programs have shown great responses under the **DNFTSU** management system as well.

Quality alfalfa <u>tends</u> to grow:

- Deep dark green in color

- With soft fine stems (not woody) that are actually palatable to your cows
- Tall, not bushy in appearance and may have the tendency to lodge
- Large "quarter" size leaves (unless multileaf variety)
- Full stemmed, not hollow (drinking straw) type
- High in pectin/sugar content (possibly high refractometer readings - but note these are highly variable due to many factors and should not be relied upon solely)
- **With balanced nutrients (ideals listed)**

Ca	1.5% or more,	Boron	40 ppm or more,	Fe	200 ppm or less,
P	0.35% or more,	Cu	15 ppm or more,	Al	100 ppm or less,
Mg	0.35% or more,	Mn	35 ppm or more,		
K	near 2%,	Zn	30 ppm or more		

- A 1:1 Ca:K ratio is ideal
- Crude protein near 20%
- Nitrogen : Sulfur ratio of 10:1
  (Nitrogen is found by dividing crude protein by 6.25.)

Note: Just a note regarding testing for mineral content and balance would be appropriate here. It is generally recognized that wet chemistry lab *measurements* are much more accurate when testing for minerals than are NIR (near infrared reflectance) *estimates*. Also legume/grass mixtures will alter the "ideal numbers" and should not be considered poor quality due to genetically lower calcium and magnesium levels. **Legumes** may tend to run higher in copper and zinc as well, while **grasses** are stronger on phosphorus and manganese. Keep in mind that multiple factors affect nutrient uptake and there are no simple formulas to precisely predict.

The general idea is *well mineralized* and *balanced* within reasonable ranges - no extreme excesses or deficiency. A target ideal forage to be harvested and stored as hay or haylage would be an alfalfa/grass forage mix that tests out at 20% CP, 28 to 30% ADF and 38 to 43% NDF *while still hitting near all of the above mineral numbers*. Forage like this if stored and fed properly can make a lot of milk at low cost! For more information on species selection, ADF, NDF, etc., please read on or consult other titles listed on this website.

I understand your definition of quality. I have never been told how soil fertility and management can affect anything other than yield. I have never paid much attention to the balance of minerals in my alfalfa and have focused primarily on cutting it young and storing properly. What do you suggest I do to improve "quality" as you have defined it?

You have done well to recognize the need for timely harvest and rapid/proper storage.

Anyone can agree that the finest forage in the world is worth nothing if it is not harvested and stored properly. **DNFTSU** recognizes that there are three pillars upholding the delivery of quality forage to your cows:

Soil management and ***balanced*** fertility.

Timely and rapid harvest.

Ensiling with a rapid and complete stabilization via lactic acid fermentation and /or compression and seal (balage). This will require the elimination of oxygen and adequate sugar (plant or added) and may be aided by the use of a silage inoculant.

***If you do not achieve these "pillars" with success, you will not be successful in your transition to a high forage ration*,** which is the goal of **DNFTSU** and brings the financial rewards required to maintain a profitable dairy operation. Be sure to read on to get more details on harvest and storage management.

Note: Graziers won't have obstacle No. 3, but pillars 1 and 2 still apply - and No. 2 can be a difficult process to manage! Nevertheless, many do very well with those four-legged "haybines"!

* * *

Negatives to avoid

- Over application of manure between alfalfa or other legume/cool season grass mix forage cuttings. This can result in higher nitrate and potassium levels. You will then have forage of low sugar/pectin content and possibly residual "*composting*" microorganisms from manure - both of which will make it difficult to make good silage. Ideally manure should be applied in the fall on corn stalks to aid in their decomposition or on alfalfa only after the final cutting. If you must apply, use the rule of *a light coat over many acres* and be sure to seed some companion grass with your alfalfa (preferably perennial rye) to act as a *nitrogen scavenger*.

- Application of straight nitrogen (urea to grazing paddocks, etc.) or highly soluble potassium fertilizers (such as potassium chloride). Research has shown that imbalanced applications of these nutrients results in production of forages that are unbalanced in mineral content (low calcium and magnesium, high potassium), poor in protein quality (nitrates, etc.), and low in nonstructural carbohydrates (digestible plant fiber/pectin/sugars - energy). Creating these unbalanced forages via the soil fertility program can result in significant animal health problems including, but not limited to, poor fertility/reproduction, fresh cow metabolic disorders (such as milk fever and/or grass tetany) and general loss of body weight and poor production. Furthermore, chloride containing fertilizers such as 0-0-60 or 0-0-62 are a poor buy because they contain nearly 1/2 chloride (47%). (Something livestock manure provides a more than adequate supply of!) The excess "trace element" (chloride) and high solubility of K-chloride "shocks" the soil life and creates imbalances in forage nutrients which may negatively effect fiber and protein quality/digestibility of the plant. (Due to lack of sulfur uptake because of competition with chloride.) For a little trivia - It is known that tobacco growers cannot use chloride containing fertilizers due to the fact that the excess chloride changes the leaf fiber in such a way that it will not burn properly. Potassium chloride is as good for your soil/forage crop as it is for your gravity wagons and fertilizer boxes. ☺ Although chloride is a *necessary* *trace* element, it is all too often applied in extreme excess. Finally, excess chloride in the soil results in excess chloride in forages that, in turn, significantly reduces their palatability to the cow.

- Dolomitic (high magnesium) lime on soils with high base saturation of magnesium. Dolomite is generally less effective as a calcium source - it is less soluble and has a high ratio of Mg:Ca. If your soils contain adequate levels of magnesium already, **application of dolomite can create (or maintain) an excess which will result in tighter soil structure.** This tighter structure (produced chemically by excess magnesium) will reduce aeration and negatively effect soil life and the balance thereof. This will result in less nutrient availability *and a greater dependence on fertilizer inputs* (especially N and K). Water infiltration will also be negatively affected (surface crusting will be promoted) reducing drought tolerance of your fields/paddocks. If you have a low pH (6.8 pH or less) and low base saturation of **magnesium**, then dolomite would be fine.

Note the following information on *salt index** of common fertilizer ingredients as well the list of benefits that sulfur provides when using potassium *sulfate* in place of *chloride*:

Fertilizer Ingredient	**Salt Index**
sodium nitrate	100
ammonium nitrate	104.7
calcium nitrate	52.5
urea	75.4
potassium chloride	116.3 highest!
K-Mg-sulfate	43.2
potassium sulfate	46.1

*Salt index is a good measure of the potential for a fertilizer ingredient to cause root burn or salt injury to crops.

The benefits of sulfur (over chloride): sulfur promotes protein production, vitamin formation, chlorophyll formation, enzyme activation, fat and oil formation, carbohydrate formation and seed development. I am of the opinion that potassium sulfate is well worth the extra cost!

* * *

I'll punctuate these thoughts with an excerpt from the book Forage Management in the North by Dale Smith, ISBN 0-8403-0404-8 (emphasis added).

> Legumes need liberal amounts of soil K for maximum herbage production and persistence. Application of K to legumes usually increases the K concentration of the herbage, but also may decrease herbage levels of Na, Ca, and Mg (Reid and Jung, 1974). One of the best recognized of animal disease problems associated with K fertilization of grasses is hypomagnesemia or grass tetany. It appears, however, that the application of high rates of K also may decrease the herbage levels of other minerals as well as those of Na, Ca, and Mg. The influence of increasing K topdressing rates (applied as KCl) on the chemical composition of the total seasonal herbage of alfalfa was studied at Arlington, Wisconsin, during 1972 (Smith, 1975), the third year of production . . . *Increasing rates of K* (0 to 1,000 lb./A) significantly *increased the*

> *concentrations of K* (0.89 to 3.68%) *and Mn* (44 to 55 ppm) in the herbage, ***but significantly decreased the concentrations of total nonstructural carbohydrates, N, P, Ca, Mg, S, Na, Cu, Zn, and B.*** Concentrations of Fe and Al in the herbage were not effected. *The lowered concentrations of elements in herbage with K fertilization not only have* **implications in animal nutrition***, but with regard to the sufficiency of elements in the plant tissue for maximum growth and productivity.* When K is made sufficient by increasing its availability by topdressing, other elements may be decreased to below sufficiency level in the herbage. In the above study, percentage of S was at sufficiency level (near 0.3%) in the herbage, but probably was below sufficiency (0.22%) at the 600 pounds per acre K rate, where maximum herbage yields were obtained. Thus, *only with a complete elemental analysis can one be certain that all elements are at sufficiency level, and analysis should not be limited to only the major elements, such as K and P.*

* * *

Following these basic recommendations will *change* your forage quality. I will summarize this section with the words of Allan Nation, Editor of The Stockman Grass Farmer (Dec. 1994, p. 1, 7-9 and Jan. 1995, p. 13-16), emphasis [and comments] added:

Making Pastures "Dairy Quality"

> Too often we think of pasture as a grassy field that can support calves and some beef cows. Too often we don't lime or fertilize our pastures to increase their forage production and quality, since "it is cheaper to feed good alfalfa hay and grains."
>
> Sorry, that's just not true. It is much more economical to be able to feed livestock on pasture, that are usually fed grain or legume hay. The catch is, the pasture must be high quality pasture. It is likely that most farmers don't really know what "dairy quality" pasture looks like.
>
> **High quality pasture** is dense with high-TDN grasses AND legumes, and relatively weed-free. The soil is loose and well-drained and can soak up heavy rains. It is high in humus and alive with earthworms.
>
> Such "high-energy" pastures do not just happen. They are created and maintained by careful management. It requires proper grazing, occasional reseeding *and frequent inputs of lime and fertilizer*. But the results and the long-term increase in profitability are well worth it.
>
> **If the forages we grow had the energy and minerals that animals need, we would not have to buy expensive supplements, pay medical bills or make so much hay.**
>
> **Organic matter is nature's fuel** for pastures. The dead roots that naturally result when grasses are cut or grazed are the food for soil microorganisms. The decay of organic matter releases the nutrients it contains, and also the activities of microbes release acids which break out the tied-up nutrients in soil minerals.
>
> Organic matter also gives the soil a porous nature that allows it to "breathe" and lets oxygen in for roots, and carbon dioxide out. Soil humus can soak up large amounts of

rain and hold it for dry periods. Tests have found that grass crops can absorb 87% of rainfall, compared to 70% for a field of corn.

But organic matter can be destroyed. Tillage and **growing row crops** quickly lowers the soil's store of organic matter. **Overgrazing** a pasture does the same, since grass roots are a "mirror image" of the tops, and cropping off grasses too short causes the root system to shrink. High temperatures or hot climates cause soil organic matter to oxidize away. **Leaving soil bare in the summer** will have the same effect.

Organic matter can be built up in a number of ways. Avoid the things mentioned in the previous paragraph. Also, avoid adding too much raw manure or carbonaceous crop residues, since they will over-stimulate soil microorganisms, with the result that available nitrogen will be tied up. Compost is better than manure, but growing grasses in a rotation **-** or a permanent pasture **-** is best of all for increasing soil organic matter. A pulsed or rotational grazing system is much better for keeping grasses or legumes in peak production, and for building soil organic matter as well.

High-energy, high-TDN grasses such as **ryegrass**, as well as perennial clover, **require high soil organic matter**. Part of the reason is that soil humus helps them survive hot or dry periods.

Fertilization is also necessary to build high quality pastures. First, adequate **calcium,** usually from a liming material, is very important, for several reasons. Calcium improves soil structure by causing soil particles to clump together, which allows the soil to "breathe." **Calcium** improves the availability of phosphorus, nitrogen and trace elements. **Calcium** increases the populations of soil microbes and earthworms, which aid in nutrient release and improve soil structure. Improved soil helps forages survive drought better. **Calcium** helps prevent infestations of certain weeds, such as dandelion, chickweed, plantain and buttercup. Legume forages require a lot of calcium, and high calcium improves the palatability of grasses and legumes. Some farmers find that livestock are more docile and content after pastures are limed.

Applying liming material frequently in smaller amounts each time is better than large amounts every few years. Lime should not be applied just for pH control. The pH does not depend on calcium, since a soil can be high in pH but low in calcium. Calcium can also be applied in **gypsum** (calcium sulfate), which will not raise pH (plus gypsum contains sulfur).

After calcium, **phosphorus** is the next most important element for quality pastures. Phosphorus is essential in every living cell, plant or animal. Phosphorus-poor forages lead to unhealthy, unthrifty livestock. Because phosphorus is abundant in plant seeds and animal bones, much of it can leave the farm with sales of grain and livestock. Research at Ohio State University found that the milk from 130 cows completely drained the available phosphorus from the top six inches of one acre of pasture soil.

Although there is a lot of phosphorous in soil, nearly all of it is tied up by other elements - calcium, magnesium, iron and aluminum. A frequent application of a phosphate source is important for maintaining a quality pasture. It is necessary for good growth of high-energy grasses and legumes. Many farmers are using rock phosphates such as North Carolina rock phosphate for pastures in preference to the highly available phosphorus sources such as superphosphate. Addition of liming material increases the availability of soil phosphorus.

Adding phosphate materials to animal manure is a good way to reduce odor and save nitrogen that would otherwise escape. The phosphate ties up ammonia as ammonium and keeps it for later release by soil microorganisms.

[I would not agree with the above strategy on phosphorus management *unless* soil test data reveals *very low* levels of phosphorus. As soil phosphorus exceeds 30 ppm, all applications of phosphorus need not (*should not*) exceed crop removal. –TW]

Potassium is need for plant growth, but too much of a good thing is bad. High potassium intake by animals can lead to health problems, especially in animals being fed supplemental grain. Spreading too much potassium - rich manure on fields is often the source of the problem (composting it is a better practice). Potassium is not exported off the farm in milk or animals' bones. [In error here. Milk is a rich source of potassium. Also, do not compost unless you are *sure* excess potassium is a problem –as potassium is often leached out of compost.]

Grass tetany is usually considered a disease resulting from cows eating low magnesium feed, but it can also result form forages that are low in phosphorus and high in potassium and nitrogen. This imbalance causes low magnesium assimilation by animals.

Milk fever is another health problem that is being recognized to be caused by out-of-balance, high potassium feeds, especially in grain-fed, dry and close-up cows. Dry and springing cow forages should not generally contain over 1 to 1.5% potassium.

The use of highly soluble potassium fertilizers is not good for pastures. Potassium chloride (muriate of potash) can lead to animal health problems. Potassium sulfate is better since it also contains sulfur, and sul-po-mag is also a good material.

Trace elements are too often left out when it comes to fertilizing pastures, yet small amounts of them are just as necessary as are the major nutrients. Boron is important for good legume growth, for example. A complete soil test, including trace elements, is necessary to build and maintain a high quality pasture.

*   *   *

If Alan's words are not enough, did you see the article titled "New Zealanders make nearly 2 1/2 times their US counterparts" in the March 10, 1996 issue of *Hoard's Dairyman*? It was written by Ian M. Brookes. I found it interesting how the New Zealand farmer focuses more on milk per acre than milk per cow. Following is a table that was contained in the article to compare income and expenses.

I hope you will take special note of the differences in spending especially on feed and fertilizer. Again, the article claims New Zealanders net profits are 2 1/2 times that of the average American system. (Please note that I am not suggesting that all farms go to strictly a grazing program without any grain supplementation. What I am suggesting is that it may be much more profitable to *grow quality nutrition* than to *attempt* to buy it.) (Emphasis and notes added.)

US $/100 lbs. milk	New Zealand	USA
Income		
Milk	8.42	13.23
Other	1.29	1.97
Total	9.71	15.20
Expenses		
Feed	***0.80 (Low!)***	***3.86 (Wow, much higher!)***
Fertilizer	***1.04 (Higher, but . . .)***	***0.44 (Low!)***
Other	1.84	6.55
Direct	3.68	10.85
Overheads	1.69	2.70
Total	5.37	13.55
Net surplus	4.34	1.65

* * *

When I get started on your soil program, should I reduce the level of concentrates that I am feeding my cows and increase the percent of forage immediately?

Yes and no. *We need to find out where you are at right now* before that question can be answered. **Whatever you must do, must be done gradually** (unless there is some gross error in your feeding program that must be dealt with quickly such as the entire herd in a state of acidosis, etc.). As a rule, **I do not recommend feeding a lactating cow any less than 2% of her body weight in dry matter as forage.** Therefore, a 1400# cow should be getting at least 28# of forage dry matter and a 900# cow should get no less than 18# of dry matter from forage. (**Corn silage should not be given full credit** as forage. By rule of thumb, consider it 1/2 forage and 1/2 concentrate on a dry matter basis –in other words, one must account for the grain content.)

Conversely, *to maintain health*, a cow should *never* be fed more that 1/3 of her normal level of milk production as concentrate (corn plus protein supplement) and it should never exceed 1 1/2% of bodyweight on a dry matter basis. Although these guidelines may be considered “old” rules of thumb, *they nevertheless hold true*. What has changed over the years is that we have become short sighted. Yes, it is true that we may be able to get a little more milk from the cows *short term* by breaking these rules, but unfortunately *the farmer* ends up paying for more than this milk is worth because of herd health/cull problems *in the long term*. (Review the basic differences in philosophy between the conventional nutrition and the **DNFTSU** program in regard to achieving maximum profit.)

If your current ration programming does not fall within these rules of thumb I would strongly recommend that you work to get it back in line as soon as possible. Keep in mind that if your cows have been foundered (acidosis / laminitis) on the high concentrate program, you will have a lengthy healing process to work through. (For more helpful/practical rules of thumb to use in your feeding management, read on and/or consult other titles on this website.)

Does this mean then that the* DNFTSU *program is opposed to high milk production and I must expect to have lower production under this program?

Not at all! I don't want you to feed them like dry cows to get milk like dry cows! What I am opposed to is ***unprofitable*** levels of milk production regardless of your rolling herd average. ***Every farm will have a different level of milk production that will be it's very own most profitable level.*** This will depend upon many variables including the genetic potential of the cows, *actual* forage quality, cow comfort, individual herdsmanship, etc. It is probably safe to say that both ends of the spectrum can be unprofitable, very low rolling herd averages *as well as very high ones*. (We all know of farms that were driven to financial ruin trying to achieve the highest rolling herd average in the county.) Why would any dairyman want to spend money to push for higher production if he gets no return (or less) on the investment?

The highest net profit will not be found by merely focusing on short term income over feed cost, but by also recognizing long term herd health and turnover factors. The goal should be maximizing milk per acre at the lowest cost of production per hundredweight. **This puts the emphasis on *pushing* for maximum forage quality and yield in place of *pushing cows*.** (It also free's your cows to maximize their *lifetime* milk production while providing you a low enough cull rate to support livestock sales - adding even more to profits!)

To answer your question regarding *production* expectations (and I hope *profit* means more to you), I must admit that you are probably considering the wrong program if you still have your heart set on being manager of the top RHA in the country. However, if **your interest is more in the area of achieving 20,000# plus RHA (holsteins, no hormone shot) without using supplemental protein and feeding no more than 15# of shelled corn per day (or the equivalent in other starch sources - small grains, etc.) while force feeding minimal amounts of supplemental minerals, having a *voluntary* (you choose) cull rate of 20% or less and heifers to sell every year - we would probably find your goals and the DNFTSU program compatible.**

If the picture I have just painted seems unbelievable, I do have references and logical reasons why this can be duplicated. *Some* herds *far exceed* this level of milk production. The basis is very high quality forage, consistently. (Keep in mind that the duplication process will involve more than merely feed programming and a couple of changes in the soil fertility program. *There may need to be a duplication of some of the management practices and style of some of the successful farmers* that employ the **DNFTSU** school of thought. Please do not be offended at mention of this, I just want to do credible, honest consulting work.)

How will I know when I can begin to decrease the higher levels of corn and supplement that I have been feeding without taking a big loss in milk production or body condition?

Of course every farm situation is a little different and it will be helpful if you are working closely with your vet. **Study the information on this website**. I must stress that **this transition process will be nearly impossible to do without *your* daily involvement as your own *truly independent* "nutritionist".** I have seen many farmers get back in control of their feed programming and feed costs when on this program and their *willingness to take responsibility* *for their feeding management* was key to their success. In fact, some have become so comfortable adjusting their rations by *observation* (cow bio-feedback) that they do a ration *estimate* (calculation) no more than three to four times per year.

This brings us to the "how" part: Observing the cows, this is the key. **Modern desktop feed management has gotten everybody so caught up in "crunching numbers" (*chemical* measures) that we have forgotten to look at the cows.** Keen observation is the *only* way to monitor the ***physical*** and ***biological*** success/failure of a ration. You must train yourself to recognize the basics of what a balanced ration *looks like*, not only on paper, but *most importantly in the barn.* There are a few basic indicators that need to be monitored in the barn before we can expect our final indicator in the milk house to be high and remain there at a relatively low cost.

Cows send us signals in their behavior (rumen fill and cud chewing habits for example) and then there is the manger and the gutter. You must know what proper digestion *looks like* after your feedstuffs make the journey from the former to the latter via your cow. You must understand how to make adjustments on supplemental feeds based on these "signals." I call feed programming that considers *nothing but dipstick readings* as the judge of success "*dipstick mentality."* (For more information on fine tuning the ration by observation, consult other titles on this website.)

It will suffice to say here that your focus as a dairyman who is just beginning on this program should be on *forage management*. Whether you graze or confinement feed your cows **quality forage is the key. If you will work under the principles of DNFTSU to grow, harvest (or graze), store, and present forages to the manger that tend to appear and test similar to the ideals that I have described, this goal of a high forage ration will certainly be within your grasp.**

As you work on your forages, train yourself to begin focusing on your cows to *manage the rumen fermentation* by simple time honored principles of observation mixed with a little technical knowledge of what is really going on in there! Use the information on this website to teach yourself how to do your own ration *estimate* (consider, this is only *a "ball park"* calculation, no matter who does it). *The reduction in the need for high levels of feed supplements to produce high levels of milk will gradually and automatically be realized as forage quality increases and is fed in such a way to allow the cows to be the final judge of* ***true*** *quality.* When the *cows* begin "telling" us they are getting excess protein and/or energy, we *then* start backing down on the supplements. **DNFTSU's** motto is "push the forage, not the cows."

When feed programming is considered to be more than a mere exercise in calculating the *chemical* nutrient needs but rather includes evaluation for adjustment for *physical* and *biological* needs/response, you will move on to more successful (and economical) nutrition.

* * *

At this point, I would like to include two articles that discuss and confirm some points of the **DNFTSU** program in regard to feeding management. Neither of the articles make the soil-forage quality connection, but do a fine job once we reach the manger. I include them as an *independent* confirmation that I am not alone in my observations of and promotion of *high forage rations*.

The first article is by A. J. Kunkel, DVM, Cold Spring, Minnesota in The Compendium, January 1996. I have included excerpts only due to length. There is also a lot of promotion for TMR feeding here which is a fine way to feed cows and to be able to measure what they are eating, but not the *only* way to feed cows. One must recognize that a mixer is simply a helpful tool and not magic. Cows were doing well on good forage before we even started *measuring* DM intakes! TMR mixers are a helpful *tool* so long as we use them correctly - the hammer can pound a nail or it can pound my thumb. The real key is forage quality (*true* digestibility) coupled with proper herdsmanship/ feeding management. (I assume Dr. Kunkel would agree!) Emphasis and [notes] added.

Production Management
What Total Mixed-Ration Feeding Has Taught Me

I am a consulting nutritionist. Balancing rations for *total mixed ration feeding versus component feeding* has led me to some surprises and to the modification of previously held concepts. I have found that high-producing dairy cows can eat more dry matter than expected, if they are encouraged to do so. Also, because the composition of the end product, milk, varies little, perhaps the dietary ingredient level of the ration can also be fairly stable over all production levels. In other words, because butterfat derives primarily from fiber, high producing cows need more fiber than do low producing cows. Total mixed rations automatically solve this problem. A cow that craves more concentrate can only get it by eating more forage as well.

Consider a cow that is producing 100 pounds (45 kg) of milk per day but that could give 120 pounds (55 kg). If fed by hand, this cow would probably be fed 7 more pounds (3 kg) of high energy concentrate. With total mixed ration feeding, the cow might eat 3.5 pounds (1.6 kg) more concentrate and 4.5 pounds (2 kg) of additional forage. Apparently, cows usually can and will eat these amounts.

Energy level of the diet appears to be less important than dry matter intake and completeness of digestion. This becomes apparent as we attempt to fine tune the ration. Often when the amount of added fat in the ration decreases, milk production holds, the protein level of the milk increases, and dry matter intake increases.

When 1 pound (0.45 kg) of grain is removed from the total mixed ration, milk production increases for 40% of the cows. Again, dry matter intake increases and the character of the manure improves. Fewer animals have loose stools, and there is less evidence of undigested grain in the manure. Often, removal of a second and third pound of grain yields further positive results. **When forage quality is good, remarkably low levels of concentrate are needed. . .**

It might be easy to assume that the increased production came from maintaining a stable ruminal environment, thereby maximizing fermentation in the rumen. Certainly, this is responsible for some of the results of the proper feeding of total mixed rations. Yet at the same time, other factors play a part. .

Dry Matter Intake
In the Upper Midwest, total mixed ration feeding is a relatively recent phenomenon and is used with varying degrees of success. **When it is successful, the cows' appetites are expected to be not only good but nearly voracious.** [Yes! If we have *digestible*

fiber/high pectin forage. If the cows are getting unbalanced, lignified, coarse textured, *belly filler,* intakes will be poor.]

I use the following formula to predict dry matter intake:
2% of body weight + 1/2 of 4% fat-corrected milk = dry matter intake.

For example, an average cow in a typical herd weighs 1350 pounds (614 kg) and produces 70 pounds (32 kg) of 3.8% butterfat milk. The fat-corrected milk production is therefore 66 pounds (30 kg). The calculation for dry matter intake would be as follows: (1350 x 0.02) + (1/2 x 66) = 49 pounds (22.3kg). A high producing cow weighed 1400 pounds (636 kg) and produced 100 pounds (45 kg) of 3.6% butterfat milk. The fat-corrected milk production was 90 pounds (41 kg). Dry matter intake would therefore be (1400 x 0.02) + (1/3 x 90) = 58 pounds (26.4 kg). I expect herds to meet or exceed predicted levels of intake. When a herd eats less than expected **and forage quality is good**, fat or starch levels of the diet may be depressing dry matter intake. [I agree and see this often when forages are grown with balanced fertility.]

For example, one herd of 150 cows were eating what 145 cows would be expected to eat. After one pound (0.45 kg) of corn was *removed* from the diet, the cows then ate what 148 cows should eat. *After a second pound of corn was removed,* the herd reached the predicted level of dry matter intake.

The cows did not lose body condition on the lower energy diet, and production levels improved. In my experience, predicted dry matter intakes are much easier to get with total mixed ration diets. I suspect that the reason for this is that we often were overfeeding concentrate to high producing cows under the hand-feeding system. [I agree!]

Persistence of Lactation
An important goal in dietary management of dairy cows is persistence of lactation. I have found that this is usually much better with total mixed ration feeding. The response is not automatic, however . . .

I live in a Minnesota county that usually ranks among the top 10 counties in the United States for number of dairy cows. A few years back, I graphed production levels and persistence for five of the top herds in the county. Two of the herds exhibit good lactation persistence. The other three could use improvement. . . the major difference in the diet was the level of nonfiber carbohydrate. [Note regarding NFC: He is primarly refering to levels of starch here - corn, etc.] *In herds with good lactation persistence, it was appropriately 35% of the diet. In other herds, it was nearly 40% of the diet.*

One theory advanced to explain what we see in these animals is that when blood sugar gets too high, the animal secretes less bovine growth hormone [yes - that's "homegrown" rBST] and more insulin, which encourages fat deposition instead of milk production. I'm not sure of the status of this theory, but I still use it as a working hypothesis. When I see abnormal production drops from one month to the next, I tend to lower dietary starch levels, hoping to alter fermentation patterns to produce more acetic acid and less propionic acid from ruminal fermentation. Usually, this is accompanied by a return to normal milk flow, improved appetite, and less evidence of undigested grain in the manure. . .

[The following questions that Dr. Kunkel asks demonstrate that he is a real *thinker* and keen observer of cows!]

Do cows perform better when fed diets that are lower in starch?

*Is the higher production from higher peak milk or from more persistent lactation?
*Has an excessively fast rate of passage led to incomplete digestion of the feedstuffs?

*Could lower production [be the result of] lower levels of ruminal microbes as a result of subclinical ruminal acidosis?

*What physiologic mechanism tells a cow to continue to eat - rumen fill, blood sugar level, ruminal pH? This question merits further research.

The prevailing assumption that as cows give more and more milk it is necessary to allow neutral detergent fiber levels of the diet to go lower and lower needs reevaluation. In my experience, fiber levels need to be maintained at reasonably high levels to insure good health, high dry matter intakes, good milk production, and persistence of lactations. . .

I could not agree more Dr. Kunkel! I believe the key is fiber *digestibility*. Fiber digestibility is influenced by soil fertility/balance, timeliness of harvest and quality of storage.

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The second article is by Jane Fyksen, Regional Editor of Agri-View Newspaper. She wrote an article regarding the work of a man named Arden Nelson, DVM of Cortland, New York. I include this article in its entirety. I have enjoyed conversation with Arden and have encouraged him to investigate the soil connection. You'll find a great amount of common teaching / emphasis between my writing and Arden's. I hold Dr. Nelson's professional opinions in high regard. You'll see how his observations and recommendations connect with our promotion of high forage rations. In my opinion, Dr. Nelson is a top notch consultant who is living in the *real world*. Too many of my fellow advisors in the *dairy nutrition world* are doing ration work by *virtual reality* (computer numbers only). Emphasis and [notes] added.

Changing Ration Can Solve Lots of Problems

A dairy business will "purr" when the operator has control of what Arden Nelson refers to as the PURR cow management categories. Those are: Production (P), udder health (U), reproduction (R), and replacements (R).

The Cortland, New York, veterinarian contends that way too many dairymen are scratching for ways to solve cow health and reproductive problems, when what their cows really need is a ration change.

"Nutrition is responsible for everything," says Nelson. "It determines performance, health and reproduction."

Admittedly, that's somewhat overstated, but the northern Minnesota native hopes more farmers will grab the cat by the tail once and for all.

A veteran vet with 21 years of experience, a large share of Nelson's practice is working with bigger herds, average around 300 cows. In addition to "palpating cows," he helps his clients analyze records and rations. Nelson recently shared hints for diagnosing nutrition-derived herd problems with fellow veterinarians at the American Association of Bovine Practitioners convention.

A problem that's about as common as barn cats on dairy farms - and a lot of times just as stealthy - is acidosis/laminitis, warns Nelson. He estimates the upwards of 90% of herds have experienced it. It may come and go, and maybe only a few cows may have suffered. But for a "good 25%" of dairy operations this syndrome is "a very serious problem - their No. 1 problem," he remarks. [I agree completely! High starch, low fiber acidosis promoting rations are destroying dairy herds!]

This is how bad it can get. A herd Nelson helped was suffering with a culling rate of over 45%, and a 10% death loss, for a year and a half. Not on DHI, records were spotty on cow health and production. The owners saw very poor response to therapies for ketosis, metritis and displaced abomasa. For six months the incidence of DAs was 28 of 328 freshenings or 8.5%.

Milk fever wasn't a problem, **except when anionic salts were tried.** [This is an interesting comment - stresses the need to fix the problem in the soil before we get to the manger!] Cows had severe foot problems, including sole abscesses, sole bruises, white-line abscesses and false soles. The producers were sure the herd was unhealthy because the tank fat test "never is higher than 3.5% when the cows milk well." Recent BGH injections hadn't resulted in any noticeable increase in tank milk weights. [Think about that - at .35¢ per cow per day . . . what a treadmill to be on! There is a better way!]

Nelson says the owners described their herd as being "so sick that they would not even respond to an additional two to three pounds of grain per cow per day." They were convinced stray voltage was causing the whole herd to suffer from foot problems, illness, poor immune response, train wrecks in first-calf heifers, and subsequent poor milk production. [Sometimes voltage is real, most times not.]

Nelson examined milk plant records for this herd, keying on percentage of fat and protein. Daily tank weights for one month showed that pounds of milk per cow varied by as much as seven to eight a day. (Herds suffering from acidosis can cycle on their dry matter intake, causing fluctuations in milk shipped.)

He looked at two important diagnostic tools - the "cow comfort quotient" and the "cud chewing index." He did rumenocentesis to determine rumen pH. He body condition scored. And he ran a total mixed ration test mix, which yielded results that surprised the owners. Shaking the two TMRs - the test mix and the mixer mix - yielded 37% fewer particles over one-inch long when the ration was mixed in the mixer.

Their feed bill was $4.55 per hundredweight of milk shipped. "These dairy owners thought their feed bill was too large at all times, and did not realize that they should have spent around $3.75 - $66,000 less than they had spent," says Nelson, noting that's what many of his clients achieved and is close to the average spent by the most profitable herds on Northeast Agrifax records.

Nelson's diagnosis
The herd had suffered from acidosis/laminitis for six to 12 months, at least. They spent too much on grain, overfed the cows, and caused the sickness, poor treatment response, train-wreck heifers, DAs, ketosis and all the lameness they struggled with.

The herd needed very carful nutrition management and ration balancing **to wean it off too much grain**. Many cows needed to be sold, because they'd never return to profitable production.

Recent ration changes the owners had made toward more forage were steps in the right direction, but their mixer was worn out and they were overmixing rations. The hay they hated to feed had helped their fresh cows, and Nelson told them they should feed it to all milking groups.

Dry cows and bred heifers on this farm were also too fat, on the average, and shouldn't have been fed the five pounds of grain mix they were getting. It was only costing the owner money **and probably adding to the fresh-cow problems.**

The $66,000 in excess grain purchased over the year cost these farmers two to three times that much in reduced production and cow health problems. ***If they hadn't spent that money, they could have lost 5.2 pounds of milk per cow per day every day of the year and they would have still broken even.*** This should help dairy farmers to not feed extra grain to "push the cows," warns this vet.

Nelson believes this is one of the biggest problems in the dairy industry today - farmers wasting money on excess grain and then suffering for it. He ranks acidosis/ laminitis **above** mastitis and reproductive failure because it can cause both. [Amen Arden! He's right on!]

Cows with sore feet have a "tendency to lay anywhere," and that means dirty udders, he says. As for reproductive failure, cows with sore feet won't get to the feed bunk as often and lose too much condition and not breed back on time. They don't want to exhibit heat either, he adds.

Here are some specific diagnostic techniques Nelson uses that farmers can also use to keep their herds "purring."

Analyze rations
"Many computer-formulated rations fail to perform due to difficulties in management of cow comfort, feeding behavior, or simply the pitfalls of getting the right ration off of the paper and out to the cows," says Nelson.

Four rations exist at a given time for each group of cows or heifers: The ration on paper, the ration fed, the ration eaten, and the ration digested. The goal is to make sure all four rations are as identical as possible every day. [Notice: ration 4 is the one that matters the most!]

Nutrition diagnostics can be split into: computer ration analysis and what Nelson calls "cow consulting." Cow consulting occurs via on-farm diagnostics and looking at DHI records, shipped milk quality records, and "checkbook results." [Cow consulting essential, computer is not.]

"The cows do know, and they always tell the truth," says Nelson. "Cows tell us like it is, not as we wish it to be, not as we perceive it to be, not how it once was, but how it is!"

He believes the cows themselves "have all the answers," and that farmers and vets "need to be smart enough to ask them." [I could not agree more! Trouble is we are times *shocked* at what the cows "tell" us when we as nutritionists begin "*listening*." It can be very humbling and can defy some of our *rules*!]

'Heifer wrecks' case in point
First, he explains, fresh cows are more prone to acidosis / laminitis because they're not eating enough of the [forage] ration in the first place. Then you have heifers that haven't seen grain for two years. They develop four sore feet and can't get up and down in their stalls very well. And we call her "a dumb heifer," the vet remarks.

"She has four sore feet, a sore udder, a sore pelvis from having a calf, coupled with too little bedding," Nelson commiserates.

It's Nelson's opinion that "much of the potential progress in nutrition management has less to do with computerized ration formulations or diagnostic" and more to do with producing **quality forage,** "economic purchases," inventory control, cow comfort and consistent mixing and delivery of rations "of known quality and quantity." [See why I am quoting this article!? Arden Nelson is right on in my opinion.]

'Cow comfort quotient' used
One of this vet's favorite diagnostic tools is the 'cow comfort quotient" or CCQ. Simply count the cows that are in stalls and the cows that are lying in stalls properly CCQ equals cows lying properly divided by cows "in" stalls, multiplied by 100.

Notice, Nelson notes, that the equation ignores cows standing in the alley or at the feed bunk. It's an attempt to assess how many cows exerted the effort to walk to a stall, lie down and get comfortable. An "in-stall" cow is one that has at least two feet in the stall.

The suggested CCQ goal is at least 80%, with well-managed, really comfortable herds at 85 to 90% almost anytime they're checked. Nelson says cows should be lying down at least 11 to 12 hours a day, **which approximates the required cud chewing time to maintain normal rumen health for today's high-producers.**

Time lying down impacts production two ways. Blood flow through the mammary gland in cows that are lying is improved by 27% versus those standing. All nutrients for production of milk are delivered to the udder through the bloodstream.

"This may be a leap without complete data, but I assume that cows that lie for longer periods of time and more often during the day will produce more milk," he says. [I agree Arden!]

Second, stall comfort has a dramatic impact on the incidence of laminitis (the ration excluded). Work in England showed conclusively that the amount of bedding influenced the number of milking heifers with **laminitis** in a study of two herds owned by the same farmer and fed the same ration. Stall design and size were identical, too.

The only difference was that one used four times the bedding the other used (chopped straw on top of concrete). Nelson says many poorly designed stalls become suddenly "vastly improved" with adequate amounts of bedding. Bedding doesn't just keep cows clean and dry, but it's an "invitation to lie down," he says.

"Too little bedding or poor stall design or overcrowded barns or extended holding area times obviously add to cows spending more time on their feet. If a cow finds it difficult to lie down or to rise, she is hesitant to carry out the desired routine of eating many meals in a 24-hour period," Nelson reminds farmers. "We need to discourage cows from eating a big meal only after each milking. The further we can get our modern dairy cows away from slug feeding, the better we optimize rumen health and the ability to digest large portions of forage in the cow's diet."

The two highest producing herds he works with have excellent cow comfort and very high forage diets (upwards of 62% forage). Although forage quality is excellent, there are two underlying reasons such high forage rations work.

"The cows are comfortable and the dairymen have been willing to challenge cows to eat more and more forage," he notes, adding that it's been extremely valuable in minimizing off-farm feed costs, too. [Don't you think Arden would make a great promoter for **DNFTSU**? Arden, I hope you will take the time to study soil balance because you are right on track! Forage quality is the key **-** *balanced* forage via balanced soil fertility. This is the third leg to the stool.]

'Cud chewing index' helpful
Another useful tool is "cud chewing index," or CCI. Merely find the ratio of cows that are lying down comfortably in stalls versus the number that are chewing cuds during your spot check. Cows that are sleeping, in the process of lying down, or getting up from stalls are not included in the denominator because they are "not at risk" for cud chewing.

CCI equals the number of cows chewing divided by the number of cows in stalls, multiplied by 100. Nelson expects CCI to be 50% or higher in herds that are well fed with adequate physically effective fiber in the diet. Many of the best in this department will over be upwards of 65% CCI month after month.

A cow making 100 pounds of milk will make five to six pounds of her own sodium bicarbonate a day, to buffer the rumen. "We're going to put a quarter to a half-pound in the ration. It's like spitting in the wind," he compares. [Keep preaching it Dr. Nelson!]

Nelson says DAs, acidosis / laminitis, butterfat depression and "any of the above, plus high feed bills" is an indication that the cows suffer from **too little effective fiber** and can't perform like they're expected to. Remember, "all four rations" need to match, and the ration digested by the cows is the only ration that dictates results in health, production and reproduction, he stresses. [This is why I stress that watching the manure is so important.]

Cows will eat more dry matter with a TMR, and therefore can be fed less grain. While a TMR is a "tremendous tool," like any tool, says Nelson, mixer wagons can be poorly managed. "When an auger mixer is overloaded, has badly worn augers, or mixes too long, effective fiber can be destroyed.

Diagnose 'mixer abuse'
To diagnose "mixer abuse," Nelson suggests running a TMR test mix with "a spring scale, plastic buckets or a weighing tarp, a grain shovel, a dry floor and 'some exercise.'" Each feedstuff fed to one cow for one day is collected, weighed and mixed with a shovel. Compare the appearance and feel of the TMR test mix and the same TMR delivered from the mixer.

Nelson shares a couple of other "hints." Abused-fiber TMRs will feel much wetter than they really are. Moisture is released from the fiber of the silages when they are mashed. Another, he notes, is to always have the person doing the mixing participate. "This test can be so dramatic that many will not believe the test was done accurately unless they participated," he reveals.

Third, Nelson says, "This problem is difficult, if not impossible, to have if one uses a reel, paddle or tumble mixer. Auger mixers are the typical problem."

Many dairies, Nelson notes, have simply grown beyond the capacity of their mixers. Overloading leads to extended mixing times, which leads to fiber abuse. He's seen good managers accept as routine that the mixer has to run 10 to 15 minutes to get all the silage into the mix. Any mixer should mix a TMR in five or six minutes or less.

Another on-farm diagnostic tool is rumenocentesis.

"Tapping the rumens from 6 or 7 cows in each of two DIM (days in milk) categories has been a very effective method of consulting the cows," he notes, of determining rumen pH. He used it on one dairy that had a history of excessive grain feeding, but with little foot problems, due to an extremely comfortable environment for the cows. Fat test typically ran 3.3 to 3.6%, and the cows averaged 70 to 72 pounds on three-time-a-day milking. Evidence suggested subclinical acidosis, but rumenocentesis results showed seven of 12 cows with a rumen pH less than 5.5 (the important number).

Rumenocentesis is a reliable, direct method of diagnosing laminitis "syndrome," which Nelson calls "the most pervasive nutritional sin" on U.S. farms today.

It's an easy one to fall prey to because "grain is (usually) cheap and milk is valuable," and increasing grain almost always increased milk. On the other hand, increases in forage almost always decrease milk - in the short run. Feeding more grain is a "quick fix" and easier than striving for top-quality forage out of the field. [Yes, "in the short run" when the cow's rumen is scarred up from acidosis. In the *long run* milk production per lactation and *per lifetime* on a high forage ration is very good!]

What's more, a cow lame on all four feet isn't limping - and she's probably milking better, to boot, so her **acidosis** goes unnoticed. [Again, short term. It does not take long before she falls apart. I know Arden agrees.]

"Impatience bred from economic pressures and *production-driving dairy philosophies* [in place of *profit* driven] have created **too many acidotic/laminitic herds in our industry**," he contends. **"It is much easier to add grain to a needy ration than to gently wean a herd off of diets too high in concentrates. Forage-digesting bacteria require seven to 10 days to significantly change their numbers. Grain digesters can greatly change their numbers within hours."** [Cows with scarred digestive systems, stressed livers and damaged hooves take at least a dry period or more to recover, and some never do.]

<u>Put simply, low forage means low fiber, which leads to low milkfat, lame feet and low fertility - a lost farm. Unfortunately, farms, unlike cats, don't have nine lives.</u>

[Thank you Dr. Nelson, I appreciate your wisdom!]

* * *

Okay, I have decided to put a focus on starting my nutrition program in the soil. How long will it take to see some results?

Again, this all depends on where you are at right now. **DNFTSU** consultants generally estimate that it will take three to five years to change a *<u>bad</u>* soil condition and get everything working again (provided their farmer/client works cooperatively with them). If soil conditions and forage quality cannot be called "bad' in your operation and much of **your management** of soil, forage harvesting and storage and your cows (heifer program included) are **synchronized with the needs of the DNFTSU system** already, you can expect results much more rapidly. Most farmers see results from basic soil correction and fertilizer management within the first year, but I do not want to be guilty of making false claims or promoting a "miracle product" approach to problems. Keep in mind that farming itself is a ***system*** and **many** things must be done correctly for this system to work successfully.

To make an analogy: Compare your farming operation to an engine and consider your purchased inputs to be the **spark plugs**. Although the spark plugs are a small part of the system, they are very important to making the whole thing work. **The rest of the engine is your farm** and all it has to offer. Without an engine spark plugs are worthless. Oh, and one last component, ***the timing belt*** that represents ***you***, the part that makes sure things get done when and as they should! I hope this website can be the **oil** that lubricates the whole process by providing information and ideas to keep you *going*!

How do I get started?

Your first step is to assess the health of your soil and forage by examining its <u>physical, biological and chemical</u> properties. This includes soil and forage testing. All good nutrition programs start in the soil. What you can grow you do not need to buy, and what needs to get corrected cannot always be corrected with expensive feed supplements. Even when it can, there is less money for the farmer at the end of the month.

As you may anticipate, a good place to start is to walk your fields with a spade in hand and evaluate soil structure (dig for evidence of hard pan/root stopping areas and crumble the soil in your hands) and any clues to it's biological health (earthworm activity, recycling of organic matter, odor, etc.). You will also need to pull some soil samples and mail them to a lab for testing. Here's *<u>one</u>* I would recommend: **Midwest Laboratories, Inc.**, 13611 B Street, Omaha, Nebraska, 68144-3693, ph 402-334-7770, fx 402-334-9121 and ask for information on doing a *complete* soil test including C.E.C., % base saturation, and trace minerals. They can also provide you with any information you may need on how to properly sample a field as well as provide any equipment you may need (like a soil probe).

You may also wish to work with *your* **local**, in-state, *reputable* soil testing lab. There's a reasonable argument that can be made for doing your ***soil*** (not forage) testing nearest the soil you farm –as this lab (if recommended by your state university) should know best how to *properly* test your soil. Whatever / which ever you do / choose, stick with the same lab for *consistent testing protocols*.

Here in Wisconsin the KOWboyz use the following lab for all of our soil *and forage* tests. I would highly recommend that you use their *forage* analysis services so as to receive the KOW Consulting Association custom reports: Rock River Laboratory, Inc., PO Box 169, Watertown, WI, 53094-0169, www.rockriverlab.com, phone 920-261-0446, fax 1365.

This ends my question and answer section. If you still have unanswered questions, subscribe to this website and don't stop reading!! There is plenty of information here to guide you!

As you find and eliminate limiting factors in your farming system I look forward to hearing of your success.

Sincerely,
Tom Weaver

Six Rules of DNFTSU Dairy Management:

(Rules for the Production of Good Food **and** Good Profits)

1. Livestock are raised in healthy (clean and ventilated) environment and are handled humanely. This is the first line of defense against sickness and disease in the animals.
2. Cattle are given feed that has been produced under principles of **DNFTSU**. All ruminants are fed a diet consisting primarily of forage (not concentrates) –*calves* included.
3. As a preventative to ill health, the cows/calves are kept on a high plane of nutrition utilizing quality nutritional supplements whenever necessary (not including unproven "snake oil" products).
4. Cows/calves are properly vaccinated according to local veterinary instruction and are de-wormed whenever necessary.
5. Cows/calves are not continuously fed antibiotics as is common in many production programs. Antibiotics are used as a treatment only when absolutely necessary to save the health/life of the animal. Abuse of antibiotics are recognized as a short-term solution and a "band-aid" that does not deal with the root cause.
6. Cows are not injected with synthetic hormones in order to promote enhanced growth/production beyond their **natural genetic ability**. Reducing purchased feed costs via improvement of homegrown feeds is recognized as a far more profitable venture, as it increases productivity without reducing the health/life span of the animal or the quality / marketability of the animal product (milk). (This does not exclude vet recommended use of hormone shots to aid reproductive health programs.)

What is a DNFTSU Farmer?

- A farmer that looks to solve the root of the problem instead of artificially band-aiding the problems with excessive use of soluble fertilizers and pesticides or supplemental feed concentrates and drugs.
- A farmer that looks at profit with a long range plan in mind and is not "suckered" into short term gain/long term loss plans.
- A farmer that has a true sense of land stewardship, who wants to make a reasonable profit for himself and pass along land that can do the same for the next generation.
- A farmer that doesn't make excuses, but *takes responsibility for* the majority of the management decisions on the farm and focuses on time to educate himself in order to be better equipped to make those decisions.
- A farmer that is individualistic enough to disregard the peer pressure of his neighbors or the conventional/ popular opinion of the day and take a position of leadership.
- A farmer that works for himself and thinks for himself, and who will still be in business long after the shortsighted approaches are out of style and finally proven unprofitable.