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SOIL & PASTURE:
What's in Your Horses Forage?

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Soil & Pasture Care - Part 2:

What's In Your Horse's Forage?

by Jerry Brunetti

Horses need biodiversity - not only high octane grasses and legumes, but forbs, hedgerow species including trees, shrubs, vines, weeds, and perennials.

In the previous NHM issue, *Soil & Pasture Care - Part 1*, I discussed some of the important considerations that are associated with creating a truly fertile soil that in turn produces a nutrient-dense salad bar of equine forage.

It all begins with soils that are rich in both biology and geology (i.e. minerals), but since horses eat primarily forages and not soil, it's important to have forages comprehensively analyzed to a) ascertain whether one is meeting the minimal nutrient requirements of the horse; and b) whether or not the fertility resources in your soil are mobilizing upward into the plant tissue.

Forage Protein Quality

Since grasses, legumes and forbs are a primary source of protein, it's critically important to know whether your pasture or hay is a reservoir of "true protein" or what I call "funny protein." True protein consists of a suite of amino acids that are complexes or bound together to form peptides, which in turn form complete protein chains. "Funny protein" is actually non-protein nitrogen (NPN) which may consist of free (unbound) amino acids, nitrates, nitrites and so forth.

Forages that have elevated NPN can create a host of health and production problems, including high Blood Urea Nitrogen (BUN) levels, which are immunosuppressive and stress the liver and kidneys, since these organs work overtime to detoxify and eliminate this offensive metabolite. Elevated BUN levels can also compromise reproductive performance, as well as contribute to faulty gastrointestinal function.

Unbalanced soil fertility is the ultimate culprit ... for example, applying too much manure or nitrogen fertilizer or having calcium and sulfur deficiencies. Other minerals play a "protein role" as well, including copper, phosphate, magnesium and manganese.

Forage tests really are tests for nitrogen. Crude Protein is actually the amount of nitrogen found in plant tissue, multiplied by a factor of 6.25. That's because, on the average, all protein contains 16% nitrogen. 100% ÷ 16% = 6.25. It's an arbitrary calculation and has no bearing on quality! It's not measuring amino acids, for example. So how does one determine protein quality?

Take a look at the optimum forage test table, Optimum Parameters for Forage Nutrient Density. One of the first items to pay attention to is the minerals, because when forages meet these optimum mineral target levels, they tend to also reflect other nutritional attributes such as quality protein, adequate energy, vitamins, carotenoids, fatty acids and the medicinal terpenoids and phenolic compounds such as essential oils and flavonoids.

Forage Mineral Levels

Mineral ratios are important. For example, sulfur levels need to be a minimum of 10% of total nitrogen. If crude protein is 21%, then to determine nitrogen, divide by 6.25 (21 ÷ 6.25 = 3.36% N). Ten percent (10%)

OPTIMUM PARAMETERS FOR FORAGE NUTRIENT DENSITY

Nitrogen: 3.2-3.5% (20-22% CP)	NDF: 38-43%
Protein Solubility: 50-60%	NDFd 48: 40-60%
ADF insol CP: <.90%	Lignin: 5-10%
ADF: 28-30%	IVIDMD 48: 75-85%

WET CHEM RESULTS

	Legumes	*Grasses*
Ca	1.5 - 2.0%	1.2 - 2.0%
P	0.35 - 0.50%	0.25 - 0.40%
Mg	0.35 - 0.50%	0.30 - 0.50%
K	2.0% (1:1 with Ca)	2.0 - 3.0%
S	0.32 - 0.35% (N:S Ratio=at least 1 part Sulfur: 10 parts Nitrogen)	0.32 - 0.35%
Cl	0.30 - 0.40%	0.30 - 0.40%
Na	0.15 - 0.20%	0.15 - 0.30%
Si	0.50 - 1.5%	1.0 - 3.0%

TRACE MINERALS

	Legumes	*Grasses*
Boron	40 ppm+	25 ppm+
Cu	15 ppm+	15 ppm
Mn	35 ppm+	55 ppm
Zn	30 ppm+	45 ppm
Fe	< 200 ppm	<100 ppm
Al	<100 ppm	<100 ppm
Mb		3 ppm
Co		0.13 ppm
Se		0.20 ppm+
I		0.5 ppm
Cr		1 - 3 ppm

Forages containing mineral profiles analogous to these numbers will be the optimum feeds for all livestock. Quality protein (i.e. containing essential amino acids), forage energy (sugars, fructans, pectins, glucans, cellulose, hemicellulose, fatty acids, sterols, etc.), enzymes, medicinal phytonutrients, macro and micro elements, pigments (carotenoids, phenolics, phytoalexins), etc., nourish all the organs and the immune system thereby fostering economic responses in growth, production and fertility. Nutrient dense, energy rich forages can allow weaning the herd/flock off of acid-forming starches, low in protein, minerals and vitamins.

of 3.36 = 0.34% as a minimum forage sulfur requirement in order for plants to synthesize adequate true, complete proteins. Likewise, calcium levels need to be at least 1.0-1.2% for grasses and at least 1.5% for legumes to produce not only quality protein, but adequate amounts of quality energy as pectins, glucans and polysaccharides.

The energy quotient of forages also depends on adequate amounts of magnesium (magnesium is the core element of chlorophyll, the pigment that allows plants to synthesize sugar from CO_2 and water), phosphorus (phosphorus is the core element in the energy molecule ATP, or adenosine triphosphate). Enough but not excessive amounts of potassium are needed. Too much can depress calcium, magnesium and boron. Ideally, a 1:1 ratio of calcium to potassium in legumes, and a 1:2 ratio in grasses, are healthy targets.

Forage Digestibility and Energy

When looking at energy, remember that horses are hind gut fermenters, via the cecum and large intestine. Thus, we need to know how much of the neutral detergent fiber (NDF) is *digestible* (dNDF) vs. non-digestible (also known as "effective fiber" or "roughage"). The dNDF can readily ferment into volatile fatty acids (VFAs), which are a great energy source for the animal's tissues as well as the microflora that dwell in the intestinal tract. One of the reasons that oats are the preferred cereal for horses is that 50% of oat fiber is digestible (fermentable) beta glucans and 50% is effective fiber, or roughage. Oats also have a decent protein percentage (usually about 13%) with a wide array of essential amino acids.

Lignin levels above the optimum range listed indicates forages that either are too mature or under heat/ drought stress. Fats can vary considerably and aren't given much consideration as a nutritional resource in forages. But it's quite important to recognize that forages are a very critical contributor of alpha linolenic acid (parent Omega 3s) and alpha linoleic acid (parent Omega 6s), both essential fatty acids needed by mammals to orchestrate inflammatory and anti-inflammatory responses, regulate immune function, help cell membranes maintain permeability, and regulate insulin, amongst many other functions.

Forage Effects on Metabolism

As of late, there appears to be an equine epidemic of what is referred to in human health as "Syndrome X", which is pre-diabetes or insulin resistance. High sugar forages are being blamed for such, when, ironically, in the realm of ruminants, optimizing/ maximizing forage sugar content (as well as starch, glucans, pectins) in the pasture is the "perfect world" for stockmen, plant breeders and agronomists alike. That's because forages are typically high in protein and wanting in energy (sugars and fatty acids).

Domesticated monoculture, chemically dependent pastures, tend to be uniformly high in simple sugars and low in digestible NDF, tannins and other phenolics, and the terpenoids (monoterpenes, diterpenes, sesquiterpenes and tetraterpenes or carotenoids).

Cattle on early spring lush grass usually get an overload of protein, which causes excess BUN because rumen bacteria don't have enough forage energy to balance the carbon (go foods):nitrogen (grow foods) ratio, thus permitting excess rumen ammonia to escape into the blood stream. This excess ammonia (NH_3^+), being a cation ($^+$ charge), out competes other critical cations like calcium (Ca^{++}), magnesium (Mg^{++}) and potassium (K^+), leading to metabolic disorders such as tetany, milk fever, ketosis and downer cows.

ADF	=	lignin & cellulose
NDF	=	lignin & cellulose & hemi-cellulose
dNDF	=	pectins, galactins, beta glucans & fructans
NSC	=	starches & mono & oligosaccharides
NFC	=	NSC and organic acids and dNDF and hemi-cellulose

What's this got to do with horses? Well, horses also utilize fermentation to digest forages, except their digestive ecosystem is the cecum instead of a rumen. So my estimation is that these two species suffer from a similar kind of problem with different unintended consequences. Ruminants need more fermentable carbohydrates (NSC and dNDF) to build microbial proteins and create rumen volatile fatty acids. Horses need less NSC and more dNDF to ferment in the cecum.

Forage Biodiversity

The primary problem (in both species) is a lack of biodiversity that needs to include not only "high octane" grasses and legumes, but forbs, hedgerow species including trees, shrubs, vines and perennials. Again, remember that horses need more digestible fibers, namely the glucans, cellulose, hemicellulose, pectins and long chain sugars that do better in the cecum than do simpler sugars such as fructose and sucrose found more commonly in our domesticated pasture grasses. The production of VFAs is the goal here, not to mention all the additional benefits that forages from a biodiverse cafeteria can provide: minerals, vitamins and untold amounts of plant secondary metabolites (the medicinal substances).

Australian equestrian and rancher Peter Andrews authored a book entitled *Back from the Brink*,, which was basically an environmental wake-up call to his fellow Australians regarding water conservation methods through ecological farming practices. Andrews took a trip to England back in the 1960s to visit the renowned Beech House Estate at New Market, Suffolk owned by Lord Derby and home of one of the most successful studs in England.

One of the secrets of this stud facility's ability to produce so many Group I winners was that they never plowed their pastures and they encouraged the growth of what most folks call "weeds". There has been a traditional view among English horse breeders that a good pasture should contain 80 or more different plant species! A pasture with less than 40 species was considered to be in decline. Those who subscribed to this conviction also believed that once a pasture was plowed and reseeded, it wouldn't be productive for young horses for at least five years and was unlikely to produce a Group I winner for ten years. In my 30 years of walking pastures, I would be hard pressed to find a paddock with even a dozen species, let alone 40 or 80.

COMPARISON OF NATIVE PLANTS WITH ALFALFA *(Chart 1)*

	Alfalfa	*Dandelion*	*Lamb's Qtr*	*Chicory*	*Comfrey*	*Plantain*	*Nettle Leaf*	*Burdock*	*Cleavers*	*Curly Dock*	*Yarrow (In Bloom)*	*Purslane*	*Jewel Weed*
Protein (%)	20.97	25.0	31.7	19.5	23.7	19.6	25.7	29.0	11.7	32.7	15.2	18.6	24.9
Digestable Protein (%)				14.7	18.5	14.7	20.4	23.5	7.3	26.9	10.7	13.8	19.6
Soluble Protein (%)				4.7	2.7	2.9	4.3	3.9	1.2	1.6	1.3	5.2	2
Protein Solubility (%)	50.07	24.4	18.1	24.2	11.4	15.0	16.8	13.4	9.9	4.9	8.8	27.7	0.08
Nitrogen/Sulfur Ratio	11:1	10:1	12:1	8:1	14:1	6:1	4:1	5:1	7:1	15:1	14:1	12:1	14:1
Acid Detergent Fiber (%)	32.1	19.2	15.0	32.8	29.8	34.1	22.6	25.1	40.6	19.5	34.6	26.4	12.9
Neutral Detergent Fiber (%)	43.61	30.0	21.9	46.8	42.2	45.8	34.4	36.5	49.1	44.7	43	38.5	22.2
Relative Feed Value (%)	136.2	229.0	329.0	126	145	127	193	177	108	153	134	165	330
TDN* (est. %)	63.89	80.9	85.6	63.5	66.8	64.4	4.5	71.8	57.1	77.8	61.7	72.9	87.9
ME** (mcal/lb)		1.33	1.41	1.04	1.10	1.06	1.22	1.18	0.9	1.28	1.01	1.2	1.44
Est. NE*** (therms/cwt)		69.9	74.3	54.0	57.0	54.7	64	61.6	48	67.1	52.2	62.6	76.4
NE/Lact (mcal/lb)	0.65	0.85	0.9	0.65	0.69	0.66	0.77	0.75	0.58	0.81	0.63	0.76	0.92
NE/Maint (mcal/lb)		0.90	0.96	0.65	0.70	0.66	0.81	0.77	0.55	0.85	0.62	0.78	0.99
NE/Gain (mcal/lb)		0.6	0.66	0.38	0.43	0.40	0.52	0.49	0.26	0.56	0.36	0.50	0.68
Calcium (%)	1.58	1.04	1.1	0.89	2.73	1.84	4.38	2.10	1.3	0.83	0.99	1.3	1.21
Phosphorous (%)	0.37	0.33	0.39	0.31	0.20	0.26	0.41	0.34	0.39	0.37	0.43	0.38	0.32
Potassium (%)	2.05	4.46	7.66	3.59	3.94	2.97	3.01	3.28	2.46	3.53	3.25	3.17	2.05
Magnesium (%)	0.46	0.26	0.55	0.26	0.39	0.17	0.39	0.43	0.25	0.64	0.29	0.8	0.29
Sodium (ppm)	759			0.04	0.04	0.01	0.01	0.03	0.01	0.02	0.03		
Sulfur - total (%)	0.31	0.41	0.43	0.37	0.27	0.53	0.94	0.90	0.26	0.35	0.17	0.24	0.29
Iron (ppm)	171	657	91	195	176	83	349	149	70	111	100	4419	180
Copper (ppm)	15	15	8	14	29	12	11	26	13	13	17	37	12
Zinc (ppm)	30	34	46	43	46	44	40	32	127	38	40	265	52
Manganese (ppm)	23	35	138	36	192	30	36	47	66	36	71	163	48
Boron (ppm)	50	30	44	28	42	29	67	32	15	31	26	29	26

** Total Digestible Nutrients, ** Metabolizable Energy, *** Net Energy*

COMPARISON OF NATIVE PLANTS WITH ALFALFA *(Chart 2)*

	Day Lily Leaf	*Day Lily Blossom*	*Echinacea Leaf*	*Wild Grape Leaf*	*Wild Rasp Leaf*	*Willow Leaf*	*Hazlenut Leaf*	*Mulberry Leaf*	*Chinese Chstnt Lf*	*Linden Leaf*	*Elder Leaf*	*Honey Locust Lf*
Protein	20.6	23.4	15.7	22.1	15.2	19.8	14.1	26.2	21.8	16.5	24.2	17
Digestable Protein	15.7	18.3	11.1	17.1	10.6	14.9	9.6	20.9	16.7	11.9	19.0	12.3
Soluble Protein	5.4	14.8	1.8	1.2	0.4	1.5	0.7	3.6	14.7	.06	2.5	1.3
Protein Solubility	26.4	63.0	11.4	5.6	2.8	7.5	4.9	13.7	67.7	3.4	10.4	7.4
Nitrogen/Sulfur Ratio	19:1	20:1	12:1	14:1	16:1	7:1	14:1	17:1	11:1	4:1	12:1	14:1
Acid Detergent Fiber	28.2	17.0	20	9.5	22.6	24.9	20.2	21.5	41.2	19.8	8.0	34.6
Neutral Detergent Fiber	35.7	23.5	29.3	34.6	43.1	37.6	42.3	34.2	70.9	35.3	27.4	48.2
Relative Feed Value	175	299	233	198	154	172	161	197	75	194	255	120
TDN (est.)	70.9	83.4	77.3	77.8	74.5	72	77.1	75.7	54.6	77.5	79.4	61.7
ME (mcal/lb)	1.16	1.37	1.27	1.28	1.22	1.18	1.27	1.24	0.9	1.27	1.30	1.01
Est. NE (therms/cwt)	60.7	72.2	66.6	67.1	64	61.8	66.4	65.1	45.7	66.8	68.6	52.2
NE/Lact (mcal/lb)	0.74	0.87	0.81	0.81	0.77	0.75	0.8	0.79	0.55	0.08	0.83	0.63
NE/Maint (mcal/lb)	0.756	0.93	0.85	0.85	0.81	0.77	0.84	0.82	0.51	0.85	0.88	0.62
NE Gain (mcal/lb)	0.48	0.63	0.56	0.56	0.52	0.49	0.56	0.54	0.26	0.56	0.58	0.36
Calcium	0.81	0.39	2.57	1.91	0.85	1.45	1.44	3.09	1.37	2.79	1.72	1.33
Phosphorous	0.25	0.43	0.25	0.32	0.16	0.23	0.12	0.26	0.2	0.20	0.25	0.24
Potassium	2.24	2.17	2.22	0.95	1.6	1.71	0.75	1.85	0.84	0.88	1.87	1.17
Magnesium	0.20	0.17	0.88	0.25	0.29	0.27	0.31	0.34	0.37	0.53	0.23	0.16
Sodium	0.03	0.05	0.02	0.02	0.01	0.01	0.04	0.02	0.02	0.02	0.03	0.02
Sulfur (total %)	0.17	0.19	0.21	0.25	0.15	0.44	0.16	0.24	0.31	0.19	0.31	0.19
Iron (ppm)	203	86	131	502	100	117	118	154	120	196	274	82
Copper (ppm)	10	22	21	16	18	13	19	12	15	19	14	11
Zinc (ppm)	25	66	32	32	35	105	27	36	61	26	21	33
Manganese (ppm)	54	40	132	89	210	101	373	63	160	65	48	52
Boron (ppm)	49	16	66	31	23	34	28	36	72	52	38	20

Upon reading Andrews' discovery, I reflected back upon the research I did back in 2000 during a record drought and heat wave, whereby I pulled two dozen samples of wild plants growing upon marginal soils and had them tested at the forage lab. Using a high quality alfalfa sample as my comparative benchmark, I was amazed at what was revealed, which are the comprehensive forage values listed in Charts 1 and 2, Comparison of Native Plants with Alfalfa (previous page).

Notice that alfalfa contains 50% soluble protein whereas the herbs, vines, shrubs, trees are only half that amount. That means that the proteins in the wild plants are more slowly digested, thus producing less BUN. However, all of these wild plants are very rich in total protein, yet none of them are legumes. Macro and micro elements are remarkably elevated, yet no amendments or fertilizers were applied! These plants are very medicinal. Some improve liver and kidney function; others contain anti-parasiticals (such as tannins and terpenes) to inhibit the opportunism of intestinal worms; many are antimicrobial; others contain healing and soothing mucilage and demulcents; more than a few are anti-inflammatory and even analgesic.

Benefits of Hedgerows and Weeds

One way to provide such a nutritional and medicinal "Farmacy" is to put in hedgerows, such as has been in existence in England for 2,000 years when Britain was colonized by the Romans. Researchers have found that these 10-12' wide ecological borders host up to 600 plant species, 1500 insect species (many of these are pollinators), 65 bird species and 20 mammal species. Hedgerows also create micro-climates, reducing drying summer winds and chilling winter gusts. The transpiration of moisture during daytime creates dew at night. Habitat for birds such as wrens, swallows, bluebirds (build houses in the hedgerow!) are a great source of fly control.

There has been a traditional view among English horse breeders that a good pasture should contain 80 or more different plant species!

Weeds growing in the pasture aren't really a "negative" either. Weeds can double their biomass in 10 days; grass requires 6 weeks to double its biomass. Compared to weeds and trees, grasses are a "debtor" of fertility because a) grass gets eaten (grazed) and b) grasses have a smaller solar collecting surface area than weeds and trees.

Weeds that are not typically palatable, such as docks and thistles, are profoundly nutritious and medicinal. Mowing those weeds and allowing them to wilt for a half a day allows the bitter alkaloids to break down while the sweet tasting concentration of carbohydrates increases. The mowed weeds, if not eaten, contribute biomass and vegetable matter to the soil. Mowing a weedy pasture twice a summer can increase the fertility of such a paddock by 500% (!), thereby encouraging the reappearance of palatable grasses and legumes.

Geology (minerals) plus biology, plus holistic grassland management (pasture, prairie, range, savannah) creates fertile soil and maximum diversity, which in turn provide the most nutrient dense and medicinal feeds a horse could ever ask for, while reducing, even eliminating, costly supplements, hay, feed and veterinary intervention.

About the author:

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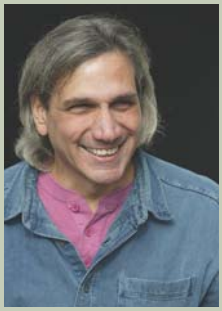

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