Summaries of Displays at the U.S. Dairy Forage Research Center
1925 Linden Drive West
Friday, June 29, 2001

General Introduction to Dairy Farming/Industry Main entrance foyer.
(Diane Amundson, Wendy Smith, Mary Becker)
From grass to your glass.
History of USDFRC
Dairy Production Data
Collaborations with USDFRC
USDFRC Mission Statement

Dairy products and their relation to milk production. Display of dairy facts number of cows in the U.S., acres of forages, total milk production, distribution of milk production, etc. This display will be in the main entrance foyer, along with handouts illustrating where displays are set up around the center. Lab personnel will be available at this location to answer questions and to direct visitors to other displays. At least some of this information/activities will be geared toward children.

Cell Wall CRIS (Hatfield and Ralph)
What is fiber, what is it made of and how do dairy cows use it? In Room 225
(Demonstration/display, Hatfield/Ralph)
Fiber is defined as that portion of the plant that is indigestible or slowly digested by the dairy cow. To the plant, fiber is the structural component that gives it a semi-rigid shape. The fiber fraction of the plant is composed of cell walls that are made of structural carbohydrates, lignin, phenolics, and protein that together form a complex composite structure like the wall of a building. Only the carbohydrates and proteins have the potential to be used by the animal and only 40-50% of these are actually digested and converted to energy. Lignin is a phenolic molecule that is not digested and acts as a barrier to the breakdown of other wall components. Although it would seem that fiber (cell walls) only has a negative impact on the nutrition of dairy cows, it actually is required for optimum rumen function and animal health and cannot be taken out of the diet. Our challenge is to find ways to increase fiber digestion by the dairy cow in order to increase efficient feed use.

Impact of increasing cell wall digestibility. In Room 225
(Demonstration/display)
Forages offer unique advantages, in addition to nutritional benefits, by providing cropping alternatives that have a low environmental impact and in many cases help to eliminate environmental problems (e.g., minimize soil erosion, provide efficient nutrient cycling, etc.). In spite of these benefits, there is a declining use of forage crops in dairy production systems due to the high concentration and low digestibility of the cell wall fraction. Because the cell wall (fiber) is critical for proper rumen function and optimum animal health we cannot simply remove the fiber from dairy cow diets and feed them more grain. An alternative is to increase the digestibility of forage cell walls that could significantly increase dairy production. For example, a 10% improvement in cell wall digestibility of forages by dairy cows in the U.S. would produce $350 million in increased milk and meat production with 2.8 million tons less manure solids and 2 million tons less in grain supplements. We are currently collaborating with researchers at the

UW and private plant breeding companies to develop forages with increased cell wall digestibility.

Cross-linking fiber limits digestion In Room 225 (Ralph & Hatfield)
Like the walls of a building, cell walls provide plants with a semi-rigid shape and structure. They give the plant strength to stand up-right in the earths gravity and to resist environmental stresses such as wind, insects, and pathogens. To accomplish this the plant forms connections between (cross-links) components within the cell wall to produce a reinforced structure. Typically these cross-links are between lignin and wall carbohydrates. Although this is a good thing for the plant it results in less digestible material for the dairy cow. We have identified key components in grass cell walls and have shown that decreasing the amount of cross-linking by these components would increase digestibility. Currently there is a collaborative project with Mike Casler (UW of Madison) to select bromegrass with reduced cell wall cross-linking.

What is lignin? In Room 225
Lignin is a complex macromolecule found in the cell walls of all terrestrial plants. The lignin molecule is assembled from building blocks called monolignols. The production of the monolignols involves many biochemical steps (enzymes). These components are chemically connected in a number of ways. Each different chemical connection has an unique 'fingerprint' we can detect by a method called nuclear magnetic resonance (NMR). Lignin assists in a plant's overall strength and structure, in water transport throughout the plant, and in the inhibition of attack by plant pathogens. Although the function of lignin is critical to a plant's overall health, its presence can be detrimental to efficient utilization of that plant. For example in forages, since lignin is highly indigestible by dairy cows, much of the nutritional value of a plant can be tied up by lignin and simply pass through the cow. In order to maximize the efficiency of the total nutritional intake, a cow must eat more forage. The presence of lignins inhibits pulping costing a lot financially and environmentally to get rid of.

The clever nature of plants to produce lignin that meets the plant's needs. In Room 225
(Hatfield & Ralph)
Lignin contained within the cell walls of plants has vital structural roles yet limit fiber digestion. Can the level of lignin be decreased without altering optimal plant growth and development? Would a 20% decrease in lignin increase digestibility without affecting production or susceptibility to disease? How much of a decline in lignin is necessary to increased digestibility? Plant mutants that are missing a given component or reduced amounts of it are useful research tools that can help us answer these questions. Natural mutants such as the brown-midrib (Bm) mutants of corn or genetically modified alfalfa that have altered lignin biosynthesis allow us to study the interactions between lignin and other wall components and their impact upon digestibility. Results so far indicate that changes can be made in lignin without a decrease in biomass production and with improved cell wall digestibility.

Demonstration of how forage samples are analyzed for structural studies. In room 361
(John Ralph Lab)

Evolution of a New Forage Variety In room 225 R.R. Smith
It takes from 11 to 14 years to develop a new forage variety from the initial selection of desirable plants to when the final product is sold to the farmer. The new variety must be superior to other varieties on the market and be animal-acceptable; high-yielding; highly

digestible; winter-hardy; persistent; resistant to diseases and insects; and tolerant to environmental stresses. To create a new variety the plant breeder must evaluate, select, and intercross plants in the greenhouse, laboratory, and/or the field to incorporate all the above characteristics into a new experimental population (new variety). This phase can be considered the "developmental" phase, and requires from 3 to 5 years to complete. Secondly, the new variety has to be tested in the field to determine its superiority to other varieties. This period is referred to as the "testing" phase and usually requires from 4 to 6 years to complete. The new variety must be acceptable to animals; tolerant to pests and environmental stresses; be equal to or better than other varieties; and survive repeated harvests each year for three to four years. Finally, if the new variety proves to be superior to other varieties, sufficient seed needs to be obtained to provide to the farmer. This is referred to as the "seed increase" phase. It generally requires from 3 to 4 years to increase 3 pounds of the initial experimental seed to approximately 1.5 million pounds, a sufficient amount to plant approximately 100,000 acres for the farmers. For example, about 3 million acres of alfalfa are grown in Wisconsin each year and one-third of this is planted new each year (1 million acres). Therefore, the 1.5 million pounds produced after four years would only be enough for 10% of the new plantings each year. Forty years ago, the perennial forage legume, red clover, was poor yielding and only survived two years in pastures and hay fields. Using the process described above, USDA, ARS, U.S. Dairy Forage Research Center plant breeders have improved red clover such that current varieties are high-yielding; resistant to diseases and insects; and survive four years in the field. The new red clover varieties have provided substantial savings to the farmers.

Forages for dairy production Display in greenhouse area Room 150 R.R. Smith & R. Hatfield

There are many types of forages that are grown across the United States. A few examples of forages that are grown in the upper Midwest include alfalfa, red clover, birdsfoot trefoil, cicer milkvetch, white clover, kura clover, fescue, perennial ryegrass, bromegrass, and quackgrass. Each has unique features that could be utilized or genetically enhanced for use in dairy farming systems.

Breeding Alfalfa with More Digestible Stems In room 225

Hans Jung**,** (USDA-ARS US Dairy Forage Research Center Cluster and Plant Science Research Unit, St. Paul, MN an JoAnn Lamb)

A breeding program has been initiated at St. Paul, MN to develop alfalfa varieties with improved stem digestibility. Stems account for much of the increase in yield as alfalfa matures, and stems have high fiber content and are poorly digested. Therefore, increasing stem digestibility offers the possibility of making major improvements in the feeding value of alfalfa. We are currently selecting for reduced fiber content and increased fiber digestibility of alfalfa stems. The first cycle of selection has identified plants that have 9 % less fiber and fiber which is 12 % more digestible than the average for current commercial varieties. Selection is continuing to further enhance these improvements in alfalfa stem quality while maintaining disease and insect resistance, winter hardiness, and yield.

The Rumen Symbiosis: A Partnership Between the Cow and Its Microbial Population In room 225 Paul Weimer

Molecular Assessment of Microbial Populations in the Rumen In room 266A P.J. Weimer, C.L. Odt, G.C. Waghorn, D.R. Mertens

Rich Muck

Inoculants-Improving Silage Fermentation In greenhouse breeze way

Inoculants are silage additives that supply lactic acid bacteria to crops at ensiling. This helps guarantee a fast and efficient fermentation in the silo. The improved fermentation reduces storage losses and improves animal performance. However, inoculants do not always work, and research at the Center has provided a way to predict when inoculants will be profitable in making alfalfa silage.

Bunker Silo Management In greenhouse breeze way

Bunker silos are becoming increasingly common on dairy farms, but they require more management than tower silos to get high quality silage. Critical management issues are packing the crop well during filling, sealing the silo with plastic, and feeding out at a sufficient rate. While farmers can easily find management recommendations, the cost of not following them is difficult to find. We have surveyed packing practices in Wisconsin and their effects on silage density, compared different types of plastic for covering bunkers, and looked at feed out practices (technique and rate). Highlights of these studies will be presented.

Bag Silos – Densities and Loses In greenhouse breeze way

Long white tubes of silage are another increasing sight on dairy farms. This type of silo storage provides a low-cost, flexible solution for small and large farms alike. However, relatively little is known about the management of these silos. Our research farm and two others in the area have been using them successfully for a number of years. Over the last year we have been monitoring the filling and emptying of silo bags made at these research farms to look at densities and losses and the factors that may affect both.

Dave Mertens:

Display 1 - Rapid forage analysis using NIRS (Rm 275)

Display 2 - Measuring fiber in feeds (Rm 261)

Responses of cows to differences in maturity and processing of corn silage

Estimating Nutritive Value using a Feed Information Expert System In greenhouse breeze way

Broderick Posters for 20th Anniversary

Reducing Nonprotein Nitrogen in Alfalfa Silage Improves Protein Utilization In greenhouse breeze way

When ensiled, as much as 60% of alfalfa crude protein gets broken down to nonprotein nitrogen (NPN); NPN is used with low efficiency in dairy cows. Scientists at the Dairy Forage Center found that NPN formation in alfalfa silage reduced milk protein yield as much as 15%. High

bypass proteins have their biggest impact in cows fed alfalfa silage. Center researchers are working on practical methods for reducing NPN formation in ensiled alfalfa.

Red Clover Silage as a Replacement for Alfalfa Silage in Dairy Cow Diets In greenhouse breeze way

Although red clover has less crude protein than alfalfa when cut at similar maturity and fiber content, red clover silage averages one-third lower in nonprotein nitrogen (NPN) than alfalfa silage. This is because a plant enzyme, polyphenol oxidase, reduces NPN formation in ensiled red clover. Results from five trials conducted with dairy cows indicated that red clover also has about 14% more energy: cows ate less feed but yielded the same amount of milk, protein and SNF as when fed alfalfa.

Rumen In Vitro Methods for Testing the Nutritional Value of Feeds In greenhouse breeze way

Over the years, scientists at the Dairy Forage Center have developed a number of procedures using fluid from the rumen--the first compartment of the cow's stomach. Rumen fluid contains the same microorganisms that digest feed inside the live cow. These rumen in vitro methods have been used to determine both the protein and energy value of forages and other feeds.

Omasal Sampling Techniques for Studying Digestion in the Rumen In greenhouse breeze way

Microorganisms living in the rumen (the first compartment of the cow's stomach) digest feed eaten by dairy cows. Rather than merely analyzing the feed eaten by the cow, it is necessary to analyze the digesta leaving the rumen to determine how much protein and energy will be available to the animal. The omasal sampling method, which involves withdrawing digesta from the omasum (the stomach compartment immediately after the rumen), can be used in rumen fistulated but otherwise normal cows to study digestion without disturbing the animal.

Milk Urea Concentration can be used to Prevent Overfeeding of Protein In greenhouse breeze way

Urea is the major nitrogen waste product excreted in the urine of mammals. Milk urea concentrations are strongly related to urinary urea excretion and protein over-feeding in dairy cows. Research conducted at the Dairy Forage Center helped establish methods to allow farmers to monitor both the levels and utilization of dietary crude protein using milk urea concentrations.

Jim Russell
Bacteriocins as an Alternative to Antibiotics In room 266A
James B. Russell Agricultural Research Service, USDA, Ithaca, New York 14853

Preliminary experiments indicate that *S. bovis* HC5 can kill ruminal bacteria with very high rates of amino acid discrimination, and it is conceivable that it could inhibit the silage clostridia that ferment amino acids. Given the information that is currently available we have formulated the following hypotheses:

(1) bacteriocin producing *S. bovis* strains could be used as silage inoculants;
(2) the bacteriocins could improve silage quality by increasing lactic acid and decreasing amino acid degradation;
(3) bacteriocins remaining in the treated silage could have a beneficial effect on ruminal fermentation.

New Products From Alfalfa **Room 225 foyer** (poster and display) Dick Koegel Paul Weimer

Larry Satter
Phosphorus requirements for lactating cows **In greenhouse breeze way**

Excess phosphorus is fed to dairy cows in the United States. Research at the USDFRC has established the minimal amount of phosphorus required by high-producing cows to be about 0.30% of diet dry matter. The National Research Council in its recent publication (Nutrient Requirements of Dairy Cattle, January 2001) recommends 0.32-0.38% dietary phosphorus. This provides a reasonable margin of safety. Most dairy producers feed 0.45-0.50% phosphorus. Reducing dietary phosphorus from current levels to recommended levels will save the U.S. dairy industry $100 million annually, and will reduce the amount of phosphorus in manure by 25-30%, thus helping the environment.

Roasted soybeans are an economical supplement for rumen undegraded (by-pass) protein
Room 225 foyer
Dairy cows poorly utilize alfalfa protein. Dairy diets containing high alfalfa silage or hay must be supplemented with a high by-pass protein. Research at the USDFRC established the conditions for properly heating soybeans to maximize by-pass protein. Between 125-150 million bushels of soybeans have been roasted for dairy cows in the U.S. during the last 10 years. Proper roasting of soybeans increases their value as a protein supplement by $3.00 per bushel.

Brown midrib corn silage for transition cows **In greenhouse breeze way**
Corn silage is playing a larger role in dairy diets. It is excellent forage, but it normally contains about 25% (dry basis) of very low quality roughage-corn stalks and corn cobs. Brown midrib 3, a naturally occurring corn mutant that contains less lignin, is commercially available in suitable corn silage varieties. Research at the USDFRC has demonstrated that improving digestibility of the vegetative part of the corn plant through use of brown midrib varieties can increase milk production by approximately 4 lbs per cow per day when fed to transition cows, and that this difference is maintained for some weeks after the transition diet is stopped. This milk production response more than pays for the loss of yield (or higher costs) associated with growing brown midrib varieties.

Grazing research at the U.S. Dairy Forage Research Center **In greenhouse breeze way**
Grazing studies with lactating cows on native pasture improved by frost seeding of red clover have been conducted. In the first series of experiments seasonal calving, either in the spring or

fall, were evaluated. It was concluded that higher total lactation milk yields could be obtained with a fall calving schedule (grazing towards the end of lactation) than with a spring calving schedule (grazing in early lactation).

An experiment was conducted to compare dry cracked corn and ground high moisture corn for grazing cows. It was concluded that ground high moisture corn can serve as a better supplement for grazing cows than dry cracked corn.

Research at the USDFRC was the first to show that conjugated linoleic acid (CLA), a potent anticarcinogen in laboratory animal tests, is typically 3-5 times higher in concentration in milk from grazed cows than in milk from cows fed in confinement. USDFRC research also demonstrated that feeding about 5% vegetable oil in the diet of confinement fed animals can increase CLA content of milk.

Mark Powell, John Grabber, Mike Russelle Integrated Farming Posters

Integrated cropping systems and nutrient management on dairy farms. In room 225

Enhanced integrated nitrogen management on dairy farms. In room 225
The sustainability of dairy farms is threatened by excessive nutrient buildup in the soil and by nutrient losses to water and air. This large effort aims to improve nitrogen management from the 'front end' (ration formulation) through the 'back end' (manure and cropping systems). Through research, we are identifying several alternative ways to improve nitrogen use on dairy farms. We also are developing an ambitious outreach effort that will transfer that information effectively to farmers, farm advisors, policymakers, and students.

Whole-farm phosphorous management on dairy farms. In room 225
The application of dairy manure to cropland is regulated based on a combination of manure phosphorus (P) content, soil test P, crop P requirements, and a field's risk to lose P to surface water. For many dairy farms, feed management could very well be the most critical element of a farmer's ability to comply with these regulations. For example, lowering dietary P to recommended levels improves a farm,s P balance, reduces the cropland area needed for manure P recycling, and also the amount of P in surface runoff. Approaches to improve whole-farm nutrient use and environmental impact must be done in partnership with the feed and fertilizer consultants, veterinarians and manure haulers hired by farmers to make nutrient management decision

Tannin-containing forage crops: A way to improve nitrogen use and profitability on dairy farms? In room 225

Well-managed grazing helps protect ground water quality. In room 225