The presentation on new technologies in forage preservation will be covering a wide range of information. Some of which you are already using on your farm, some which has just been released to you as producers and finally we’ll talk about technologies that are still in the research stage.
First, Let’s Review

Recommended Forage Management Practices

Before we talk about new technologies, let’s talk about some of the basic recommended forage management practices. We’ll be going through these first set of slides rather quickly, but I want to encourage you to consider going to the Team Forage website.
These forage management recommendations are based upon factsheets that can be found at the Team Forage website listed at the top of this slide. Myself and many of my colleagues are a part of a statewide Forage team that has helped create this website. Two of the key factsheets that I'll be referencing I wrote and are entitled: “Managing Forage in Bunker Silos” and “Managing Forage in Silo Bags”. You’ll find copies of these factsheets in your packet of information.
Harvest Considerations

- Harvest at the correct maturity and fill within three days of cutting.
- Cut alfalfa at or near 170 RFQ
- Chop alfalfa at 3/8-inch theoretical length of cut, corn silage at 3/8-inch without a processor or ½ to ¾-inch with a processor
- Corn silage moisture should be 65-70% and hay silage 60-65% moisture

First of all let’s look at harvest considerations, most importantly to note is that: “you can’t make a poor quality silage better. When talking about forage preservation if things go wrong, say you don’t cut in a timely fashion, the weather doesn’t cooperate or the product isn’t packed correctly that will ultimately effect your final product.

Forage should be harvested at the correct degree of maturity to assure desired feed quality and proper sugar content for good fermentation. Also, to reduce the risk of weather related losses, hay crops should be chopped and stored within three days of cutting.

Optimal relative forage quality (RFQ) is achieved when alfalfa is cut at or near 170 RFQ based on scissor clip or PEAQ measurements. Chop alfalfa at 3/8-inch theoretical length of cut (TLC) with 15-20% of the particles exceeding 1.5 inches long. For corn silage the recommended TLC is 3/8 inch without a processor or 1/2 to 3/4 inch with a processor.

The preferred corn silage moisture range for bunker silos is 65-70%. Seepage of forage juice can occur if forage is harvested at moisture contents above 70%. This juice carries away a high concentration of soluble nutrients, representing a significant loss of valuable feed. For hay silage the preferred moisture is 60-65%. Clostridial fermentation is more likely in hay silage if the forage moisture is greater than 65%. Clostridial fermentation produces silage containing butyric acid and is less stable when exposed to oxygen.
Packing Bunkers & Piles

• Fill bunker by spreading the forage in thin layers (less then 6 inches)
• Packing is essential for good silage preservation

When filling bunkers and piles, don't go to thick when packing. Less then 6 inches is the recommendation. Packing is essential for a good quality forage. Again, just because we added a newer technology like inoculants it isn’t going to make a difference if the material isn't packed correctly.
Bag Site Selection & Maintenance

- Locate on hard all-weather base
- Orient bags north-south
- Provide a 5% slope for drainage
- Locate away from woods, drainage areas or low spots
- Maintain an unvegetated perimeter
- Protect bags from puncture, inspect regularly for holes

To aid in forage removal and to minimize losses during feed out, place bags on an all-weather base such as macadam, asphalt or concrete. A correctly designed paved site provides an additional benefit in that it can be converted to bunker storage at some point in the future by adding walls. A firm, well drained site is essential for year-round access. Orient bags north-south to promote melting of snow and drying on sides. Provide a 5% slope away from the bags for good drainage.

Locate bags away from woods and tree fence lines. Mow weeds around the storage pad and provide an un-vegetated, 3-ft perimeter around the storage pad to discourage rodents from approaching bags. Keeping bags away from other feed sources may also reduce damage. Clean up spilled feed to avoid attracting rodents. Fence the storage pad area to exclude domestic animals. Keep children from playing on or around bags. Take care when operating equipment near bags.

Take measures to protect bags from punctures. Silo bags are punctured by a variety of causes including, but not limited to equipment, people, animals (domestic, wild), hail, etc. It is important to closely inspect the silage bags for holes regularly. Punctured bags allow air to enter, which can cause significant deterioration of feed. Any holes should immediately be sealed with tape to prevent oxygen from entering the silage mass. Most manufacturers offer special patch tapes that adhere tightly to plastic silo bags and are weather and light resistant. Commonly available duct or masking tapes are not generally suitable for this purpose and will not provide a long-term seal.
Packing Bags

• Bagging machines should be properly adjusted
• Once filled seal bags tightly, open bags cause billowing plastic, pumping air over silage

The bagging machine should be adjusted to form a tightly packed forage. The higher the density of forage in a silo bag, the lower the amount of air infiltration as the bag is opened or if the bag is punctured. Most silo bag manufacturers provide recommendations on filling bags. Some provide stretch lines on the plastic bag as gauges to avoid over-filling. Measuring the distance between the outsides of these lines will give an indication of when the bag is full or over-filled. Always follow the manufacturers’ guidelines. Also follow the manufacturer’s recommendations for adding vents to the bag to allow gasses to escape. Remember that these gasses are poisonous.

Learn to adjust the packing machine’s braking pressure for varying moisture levels. If moisture levels are high, reduce the packing pressure to avoid creating mushy, oozing silage. If moisture levels are excessive (over 70%) consider shutting down and waiting until the forage is drier. Wet silage is a poorer product and has a greater chance of freezing. If moisture levels are low, it will be difficult to distribute the silage throughout the bag. In this case, increasing the packing pressure can help.
Rich Much and Brian Holmes completed a nice Silo bag study looking at silo bag density. The following slides are results from that study.
The Study Found that:

- Dry matter losses ranged from 0.3 % to 39.9 %, 14.6 % was average
- Losses tended to be higher when silage was either to wet or to dry
- Densities varied with the operator
- Densities varied across the face of the bag

Total dry matter losses (gaseous, seepage, and spoilage) ranged from 0.3 to 39.9 percent. Average dry matter loss across all bags was 14.6 percent (similar to a well managed bunker). If the worst six bags were eliminated (47 bags total in study), the average loss dropped to 11.6 percent. Of the six with the worst spoilage, one had bird damage (30.6% loss) and the plastic burst on another bag early in fermentation (39.9% loss). Both situations were repaired, but the incidents had an effect on spoilage. High losses were generally associated with either plastic damage or feeding out drier silages under warm conditions.

Densities varied with the person operating the machine, indicating that correct operation of the bagger is critical to getting a smooth bag of high density.

Densities varied dramatically across the face of the silo bag.
Densities varied dramatically across the face of the silo bag. The density of silage around the top outside half of the bag was only about 40 percent of the most dense region on the bottom center. This suggests that any holes occurring in the top half of the bag would allow for the free flow of oxygen causing high amounts of spoilage throughout the top part of the bag.

This slide shows the average results of probing the face of 5 silo bags with the density expressed as a percent of the maximum density. The density is highest at the bottom center. Density decreases as you sample closer to the sides of the bags. This low density at the bag sides helps to explain how oxygen penetrates the silage causing major spoilage when the bag is punctured and/or is opened. Emphasizing the need to look for and patch holes at least weekly. Be sure to look near the ground level and on the top.
Once filling is complete, immediately cover the bunker silo with an air-excluding material. Plastic films have proven to be the most effective covers when properly installed. It is estimated that covering a bunker silo with plastic can return eight dollars for every dollar spent due to reduced losses and increased animal productivity.

The sooner a bunker cover is installed, the less time forage is exposed to aerobic conditions or precipitation. Once the rear portion of the forage mass is placed and packed, the plastic cover should be installed. If precipitation is expected, rolling the plastic over the surface will also protect the sloped filling face.

Plastic bunker or pile covers should be 6 to 8 thousandths (mil) of an inch thick. The thicker 8 mil plastic is easier to handle, more resistant to tears, and more resistant to oxygen diffusion.
Which photo shows the method you would not want to use? The top photo. Tires should be touching, in this photo, they are not.

Plastic must be held tightly to the silage surface and sealed at the edges. When tires are used to weigh the plastic down, they should touch each other to provide a uniform weight and to prevent plastic billowing in the wind. Loose soil or sand bags have been used to give a tight seal at the edges of the plastic. Many producers are using split tires or sidewalls to avoid the difficulties of whole tires.
At feed out, feed it out quickly. Bunker silo removal rates should be more than 6 inches/day in summer and 4 inches/day in winter. Silo bag removal rate should be more than 12 inches/day. No more than 3 days of silage should be exposed at any time. Any longer than 3 days can risk to high of spoilage.

Many methods of silage removal are used on farms. Perhaps the most common method is the bucket loader. The preferred method of silage removal with a bucket is to scrape the silage from the top, and allow it to fall to the floor. Another method is to undercut the silage several inches up from the floor and then slice the balance of the face into the cavity. Whatever removal practice is used, the silage face should remain tight and smooth. Avoid methods that result in dislodging the face. Creating gouges, cracks and potholes result in air penetration deep into the silage mass and lead to increased spoilage. Face cutters (rotating drums with teeth) have been recently reintroduced to remove silage from bunker and pile silos. These machines can leave a smooth relatively undisturbed silage face.
Let’s Move on to
New Technologies in Forage Preservation

That was a quick run through on recommended practices, let's move on to new technologies in forage preservation.
Inoculants

• Inoculants may improve the fermentation process, but... first make sure your present silage management is correct
• Remember, under the right conditions, silage fermentation naturally occurs without using inoculants

How many of you use Inoculants? Are they working for you?

Inoculants don’t seem to have as clear of recommendations as other practices. In many situations, it becomes a good insurance policy, but first assure that present silage management is correct avoid problems such as ensiling overly dry crops, poor packing density, covering improperly or low feed out rates.
Categories of Inoculants

• Homofermenters, often referred to as Lactobacillus bacteria; produce only lactic acid
• Heterfermenters, often referred to as buchneri; produce lactic acid, acetic acid and ethonal.

There are basically two categories of inoculants: homofermenters, often referred to as Lactobacillus bacteria; which produces only lactic acid and heterfermenters, often referred to as buchneri which produces lactic acid and also acetic acid and ethonal. Sometimes these inoculants are enhanced by adding a chemical inhibitor usually a proprionic or and acetic acid.
Homofermentative Inoculants  
(Lactobacillus Bacteria)

- Guarantee a fast fermentation
- Shift fermentation to lactic acid, away from acetic acid and ethanol
- Improve dry matter recovery 2-3%
- Improve animal performance 3-5%

Unfortunately, there is no good way to predict when adding microbial inoculants will be effective. In research trials, fermentation was improved 75% of the time in alfalfa silage and only 40% of the time in corn silage. Also notable, when homofermenter inoculants improved fermentation they in turn improved animal performance by 3-5%. For more detailed information on microbial inoculants please refer to other Team Forage Factsheets

Homofermentative inoculants can sometimes result in silage that is less stable when exposed to air because they are readily metabolized by some species of yeast and mold
Heterofermentative Inoculants
(*Lactobacillus buchneri*)

- Improve aerobic stability of silages by reducing growth of yeasts
- Are beneficial when aerobic instability problems are expected at feed out
- Produces acetic acid which can reduce feed intake. Trials to date have not shown any problems

Buchneri looks at the other end of the spectrum. It’s about shelf life. When you put it out in the bunker, the TMR mixer, the feed alley, buchneri extends the life of the silage during that period. Basically, what it’s doing is reducing the growth of the yeast that being produced as it sits in the bunker. It makes it more stable as you’re feeding it out. You’ll need to look at your own situation. You may not be having this type of shelf life problem, so buchneri, wouldn’t be for you.

Research to date has not shown any problems with the increased acetic acid being produced by buchneri, but it’s worth noting that high of levels of acetic acid can reduce feed intake.

If you want more information on buchneri check out the factsheet on the team forage website.
Changes in Inoculants

• Inoculant industry is looking for solutions to aerobic stability problems
• Potential solutions include:
  - Better standard inoculants with the ability to kill spoilage microorganisms
  - Use of *Lactobacillus buchneri*
  - Use of *Lactobacillus buchneri* with other chemical inhibitors

The chemical inhibitor mentioned were most commonly propronic or acidic acid.
### Aerobic Stability

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Stability, hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>97</td>
</tr>
<tr>
<td>L. Buchneri 1</td>
<td>197</td>
</tr>
<tr>
<td>L. Buchneri 2</td>
<td>96</td>
</tr>
<tr>
<td>L. Buchneri 3</td>
<td>119</td>
</tr>
</tbody>
</table>

Muck, 2000

These are some summary slides from work done by Rich Muck. This one clearly shows that in 2 of the 3 buchneri treatments the silage was more stable. Note that it wasn’t 100 percent of the time. Treatment number 2 had something else affecting it. Maybe the natural fermentation process overpowered the buchneri inoculants?
Here's another summary slide from work done by Rich Muck. Note the different fermentation process occurring in 2 of the 3 buchneri treatments. The buchneri has a higher pH, lower lactic acid, higher acetic and a higher ethanol level.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>pH</th>
<th>Lactic</th>
<th>Acetic</th>
<th>Ethanol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.87</td>
<td>5.3</td>
<td>1.0</td>
<td>0.4</td>
</tr>
<tr>
<td>L. Buchneri 1</td>
<td>4.11</td>
<td>3.6</td>
<td>2.4</td>
<td>0.8</td>
</tr>
<tr>
<td>L. Buchneri 2</td>
<td>3.90</td>
<td>6.0</td>
<td>1.1</td>
<td>0.5</td>
</tr>
<tr>
<td>L. Buchneri 3</td>
<td>4.06</td>
<td>4.2</td>
<td>2.3</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Muck, 2000
Here’s another summary slide from work done by Rich Muck. Note the different fermentation process occurring in 2 of the 3 buchneri treatments. The buchneri has a higher pH, lower lactic acid, higher acetic and a higher ethanol level.
Are there any new options for covering bunkers or piles?

Present recommendations suggest that:

- 6-8 mil plastic works
- Ground limestone or soil does not
- Molasses, sawdust, sod, or a roof only, does not protect any better then left uncovered
- Research is on-going, but to date no commercial spray-on product is available

These are standard University recommendations. Let’s continue on and look at some of the more recent releases and some on-going research.
How many have heard of?? This is a new product on the market. It has its pros and cons. For more specific details I encourage you to go to the website listed. You can also go to their website to find a local supplier. This product is made in Europe and to date I’m aware of it being sold in Wisconsin by CP Feeds of Valders and Vita Plus.
Silostop uses a thin plastic layer (1.8 mil) that is significantly less permeable to oxygen than common polyethylene. In this system, low oxygen permeable plastic is placed along the walls and across the top of the forage. A heavier second layer of plastic or a tarp is used on top to protect the thinner plastic layer. A weighting material (usually sand or rock filled bags) holds the layers in place. It is more susceptible to UV Rays. Thus the need for a second layer. Tarps will protect against bird and rodent damage as well as UV rays.
This diagram is taken from the research summary produced by Rich Muck

Plastic is placed on the walls as well as the top, a reusable woven plastic tarp is used to protect the plastic and sandbags only at the walls and seams to hold the plastic and tarp in place. Some are trying variations of this recommended technique. Using a cheap second layer of plastic instead of the tarp to avoid having to roll up the tarp. Not putting plastic on the side walls. Using tires instead of sandbags, mostly because they already have tires in stock. Of course you would need more tires then sandbags because of the lighter weight.
Here's a photo showing Silostop being placed at one of the bunkers at the U.S. Forage Research Center in Prairie du Sac.
Muck’s Research Found that Silostop:

- Was more effective at keeping oxygen out
- Produced noticeably less spoilage on the top and sides with little difference in dry matter loss at deeper locations
- Improved quality in 5 of 6 treatments; one treatment failed due to a poor seal

Mucks research showed that this new system proved to be better at reducing dry matter loss compared to traditional plastic covering systems.

The Silostop system did a better job of reducing oxygen infiltration on the shoulders of the bunker. It was more effective at keeping oxygen out. In Mucks study, one corn silage bunker had problems because the plastic was not overlapped and sealed along the wall enough pointing out that like any silage system, careful management is still needed for the Silostop system to work properly.

Dr. Muck did conclude his research findings by commenting that more: “Economic analysis is needed to assess the returns on this more costly covering system.”
Slide and data from Keith Bolsen Emeritus professor taken from K-State website. I included it in the slide show because it has some nice photos showing varying methods of covering the product. Note the sandbags in the bottom left photo.
Managing Used Plastic

Burning Plastic is Illegal

- Wisconsin State Rules, Administrative Code NR 429 prohibits the burning of most materials including rubber, plastic and asphaltic materials (shingles, tar paper)

This code is in place partly because it has been shown that fumes from burning plastic causes cancer in humans. Disposal of plastic has not been an easy task for farmer, but if at all possible, do not burn plastic.
Agricultural Plastic Disposal in Pennsylvania

- 66% Burn on the farm
- 27% Landfill
- 24% Use degradable plastics
- 20% Contract a local waste hauler
- 13% Bury on the farm
- 12% Pile or dump on the farm

* Survey of Pennsylvania Vegetable Growers

Pennsylvania has an active plasticulture industry (greenhouse, mulch, drip irrigation lines, etc.) A survey of Pennsylvania Vegetable Growers, revealed what farmers typically do with their plastic wastes. Although this data is for Pennsylvania vegetable growers, the on-farm waste handling practices are probably much similar across the United States. (source: “Production of Vegetables, Strawberries, and Cut Flowers Using Plasticulture”)
A group of my colleagues had a chance to travel out to Pennsylvania and see the plasticulture industry first hand. These photos show the variety of plastic being used. With this type of diversity of types and uses of plastic, it’s difficult to sort and ultimately be able to recycle all this plastic.
Recycling plastic has been slow because:

• It’s expensive to collect and transport
• Separating types of plastic is difficult
• Contamination is a problem
• The availability of recycled materials fluctuates
• Virgin resins for making plastic are cheap
New Korean High-Temperature Combustion Technology.

This technology is a hot-water boiler heating system that burns the plastic waste. The system preheats a series of combustion chambers to 1650-2000 degrees F for 10-15 minutes using fuel oil or kerosene, then automatically switches to the plastic pellets. In a commercial setting the hope is to enlarge the size of the plastic pellet/nugget. In the photo the burner is pulled away from the boiler for visibility. I think it looks something like a kerosene space heater (Salamander or other common names?)
Research at the University of Illinois into Edible Covers by Dr. Larry L Berger. The objective was to determine whether a starch-salt matrix (homemade play-doh) could serve as an edible cover that would simultaneously reduce surface spoilage and serve as a nutrient source. The starch-salt matrix was mixed in a mortar mixer with boiling water added to gelatinize the starch. The matrix as applied by hand using a cement trowel. After the matrix cured 3 days, paraffin wax was melted and a thin layer applied with a paint roller. The data suggests that a portion of the salt diffused into the silage creating some preservation effect. A combination of the air-tight covering and preservative effects of the salt minimized surface spoilage. Salt did not inhibit intake.
Edible Cover Hurdles

• The starch-salt product required boiling water
  - Fix: use feed-grade ingredients
• Wheat flour is expensive
  - Fix: use finely ground wheat
• The application method was not practical for commercial use
  - Fix: none to date

Found significant hurdles, 1. this starch-salt product required boiling water a costly and awkward procedure on a large scale. (using feed-grade ingredients eliminated the need for boiling water) 2. Wheat flour was expensive, a cheaper source was needed. (finely ground wheat replaced the flour) 3. needed a more practical means of applying the material. A commercial CEJCO concrete pump was used with a vertical shaft mixer and screw pump. A 50ft by 3-inch diameter hose was used to apply the product. An air compressor was attached to the nozzle to atomize the product. Food grade wax paper was applied to the surface to better seal the surface (press wheels were run on top of the paper to press it down).

Hard to envision how the application process might work in a commercial setting, but I share this idea for those visionaries in the room that might be able to find a way to make the application process work.
Edible Covers

These photos were taken from the University of Illinois website and further shows the process we have been talking about.
Forage Web Page
http://www.uwex.edu/ces/crops/teamforage/index.html

Closing slide and also on handouts for reference
Central Wisconsin Agricultural Specialization
A Partnership with the University of Wisconsin - Extension and Member Counties: Adams, Green Lake, Juneau, Marquette, Portage, Waushara, and Wood

February 24, 2004

WELCOME TO CWAS - Central Wisconsin Agricultural Specialization
Our mission is to be the primary source of research based agricultural information and education for the agricultural community in Central Wisconsin.

Member Wisconsin Counties:
- Adams
- Green Lake
- Juneau
- Marquette
- Portage
- Waushara
- Wood

http://www.uwex.edu/ces/cwas/

Additional closing slide and also used as part of the handout for reference