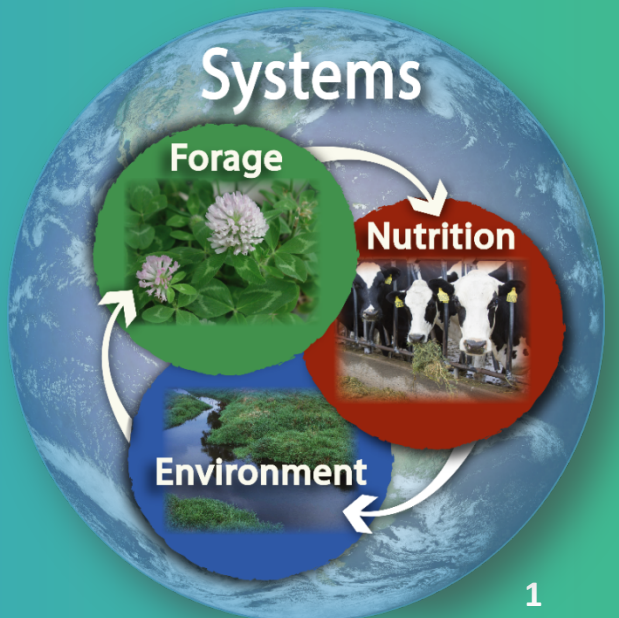
USDA
United States Department of Agriculture

Manure on Perennial Forages: Benefits and Challenges

Bill Jokela
Research Soil Scientist, USDA-ARS
Dairy Forage Research Center
Marshfield, WI

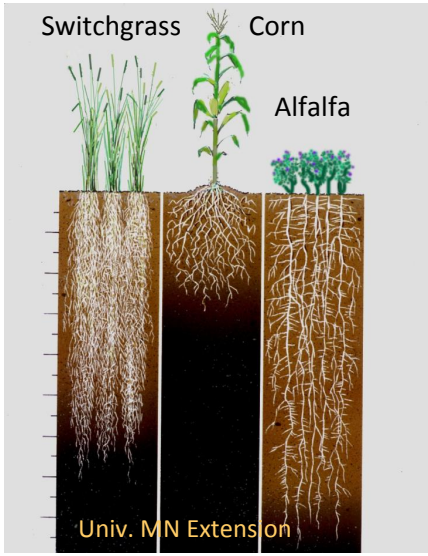
Wisconsin Crop Management Conference
Jan 13, 2016. Madison, WI



U.S. Dairy Forage Research Center
USDA Agricultural Research Service

Why apply manure on perennial forages? Alfalfa, other legumes, grass forages

- Increases acreage available for spreading
- Multiple windows of time for application
- Provide nutrients
  - Forages have high nutrient need (K, P, S, B) compared to grain crops
  - Grass forages responds to nitrogen
- Symbiotic N_2 fixation buffers N supply
- Alfalfa removes excess soil nitrate



Manure on Perennial Forages: 3 Application Strategies/Times

- Preplant: before seeding
- Following last harvest/at termination of stand
- Topdress on established stands

Preplant Liquid Dairy Manure and Alfalfa Yields

Rosemount and Waseca, MN; Marshfield, WI

- **Manure increased yields vs nonfertilized control in seeding year and first production year**
  - Except where severe compaction (Waseca) ; no yield increase in seeding year
- **Yields from manure sometimes > P, K fertilizer**
  - Sulfur and micronutrients in manure
  - Manure N in seeding year (?)
  - Soil physical and/or microbial effects
- **Manure sometimes increased weeds (seeding year)**
- **Summary: Yield increase if nutrients needed; also other beneficial effects**

Kelling and Schmitt, 2003; Schmitt et al., 1993

Manure Applications at Termination of Stand/Before Plowdown

- **Avoids potential damage to forage crop**
- **Provides N to succeeding crop**
- **BUT… often adequate N credit from alfalfa**
- **Research: Corn yield response to N 1st year after alfalfa**
  - IA, WI, MN, PA (61 sites)
    - Only 7 sites showed yield increase from N application
  - MN and other published results (259 trials)
    - Yield response to N not likely on medium-textured soils
    - Depends on length of stand, soil conditions, etc.
- **Additional N usually not needed; excess N risks nitrate leaching**

Kelling and Schmitt, 2003 Yost et al., 2015

Topdressed Manure on Established Stands

Benefits

- Another window for application
- May be yield increase
  - Nitrogen on grass forages
  - Legumes, if nutrient need

But also challenges, potential problems

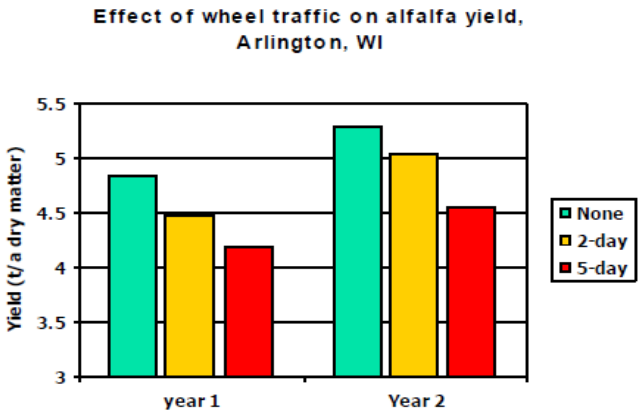
Challenges and Limitations of Manure Broadcast on Established Stands

- No N requirement for legumes, so no economic value from manure N
- May be uneven application
- Nutrient runoff, especially late fall or winter application
- Possible stand damage and/or yield loss due to leaf coating or wheel traffic
- Pathogens

Manure solids can coat leaves

- **Manure solids coating leaves**
  - Leaf scorching
  - Clogging of pores
- **Excessive rates can reduce yield**
- **To minimize adverse effects:**
  - Avoid excessive rates of manure solids
  - Application rate of solids more important than overall manure rate
  - Apply manure promptly after harvest

Wheel traffic affects yields



Causes of yield reduction

- Crack crowns (disease, reduce shoots produced)
- Break regrowing shoots
- Compaction (air, water, root growth)

Recommendations

- Apply manure immediately after harvest
- Avoid wet soil conditions
- Avoid unnecessary trips over field
- Plant tolerant varieties
- Size tractor to fit equipment
  - Minimize compaction and wheel traffic area
- Avoid tractors with duals
- Consider wider harvesting equipment

D Undersander, 2008

Manure often carries pathogens

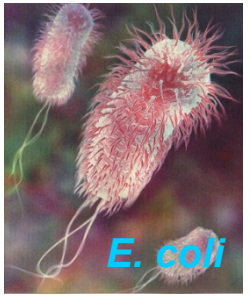
- Several zoonotic and pathogenic bacteria:

  Salmonella, Listeria, E. coli, Mycobacterium

- Several protozoa that affect human and animal health (including *Giardia* and *Cryptosporidium*)

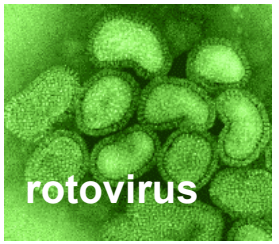
- Wide variety of viruses
  some persist > 6 months in manure

Johne's disease



Harbinson

Heyneman



Stannard

No manure from diseased livestock on hay or pasture!

Slide Credit: M Russelle, USDA-ARS

Alfalfa Yields from Topdressed Manure on Established Stands: Research Results

- **Dairy slurry on alfalfa, alfalfa-grass (MD)**
  - Manure = Fertilizer = Nonfertilized Control
- **Liquid dairy manure (WI)**
  - Preplant manure increased yield; but topdress manure decreased 20% in Yr 1, no effect in Yr 2 (wheel traffic effect)
- **Manure topdress (MN)**
  - 30% yield increase
- **Banded liquid dairy manure (Ontario)**
  - Yield response varied by cultivar (49) but all increased vs control (fertilized based on soil test); average 14% yield increase over 3 years
- **Summary: Topdressed Manure**
  - Yield increase, esp. if nutrient need (P, K, other); also other factors
  - May be no yield effect or sometimes decrease
  - Depends on balance: Nutrient response and any negative effect

Min et al 1999 Ceotto and Spallacci, 2005 Kelling and Schmitt, 2003 Bowley et al., 2009

Topdress Manure Timing for Alfalfa
Stratford, WI

- **Liquid dairy manure at 4500 gpa**
- **Application treatments**
  - No manure
  - Stubble immediately after harvest
  - 1 week regrowth
  - 2 weeks regrowth
- **Ensiled as wrapped balage**

Coblentz et al., 2014

Research supported in part by grant from Midwest Forage Association

Results: Manure Timing for Alfalfa

- **No effect on measured yield, but…**
  - Drought increased variability
  - Not main objective of experiment
- **Little/no effect on forage quality**
- **Silages well preserved, no undesirable odor or evidence of ammonia or butyric acid**
- ***Clostridium* Cluster 1**
  - Increased with manure application
  - Greater increase with delayed manure application
  - No indications of clostridial fermentation
- **Recommendations to lower risk when manure applied**
  - Apply to stubble before regrowth
  - Wilt longer (drier) before ensiling
  - Consider using lactic acid-producing inoculant

What about topdressed manure on grass forages? Nitrogen is key!

- **Reed canary grass (MN, WI, IA)**
  - Manure: Yield increase of 150 to 260% vs no N Control
- **Orchardgrass, reed canary grass (VT)**
  - 80 to 90% yield increase vs Control (no N)
  - Manure similar to N fertilizer (80 to >100%)
- **Tall fescue, 7 yrs, surface banded manure (BC)**
  - Yield increase of 100% vs Control
  - Manure = fertilizer N (equal total N rates)
- **Summary: Topdressed manure on grass**
  - Large yield increases from liquid manure
  - Yields similar to those from fertilizer N

Schmitt et al., 1999; Carter et al., 2010; Bittman et al., 2007

Alternatives to Surface Broadcast: Potential Benefits

- **Reduced ammonia loss**
  - Potential yield increase (grass forage) and environmental benefits
- **More uniform spreading**
- **Less contamination of forage**
- **Decreased runoff of nutrients, pathogens**
- **Less odor**

…but also may cause damage and reduce yield.


Drop-hose


Band/Drag-shoe


Band-aerator


Shallow Injector

Alternative Application Methods: Yield and Environmental Effects

- **Grass forages**
  - Orchardgrass, reed canarygrass (liquid dairy; VT)
    - Surface banding increased yield in 2 of 4 site-years (6-14%); reduced ammonia emission 40% (vs broadcast)
  - Tall fescue and orchardgrass (dairy slurry; BC)
    - Surface banding increased yield 7%, reduced ammonia emission 30% (vs broadcast)
    - Surface band over aeration slots (SSD) increased yield 12%, reduced ammonia 47% (vs broadcast)

Pfluke et al., 2011; Carter et al., 2010

Bittman et al., 2005

Alternative Application Methods: Yield and Environmental Effects

- **Alfalfa**
  - Ontario
    - Yield increase from topdressed dairy manure vs fertilized control (3 yrs; 49 cultivars)
      - Surface banding (14%)
      - Band-aeration (10%)
      - Effect of manure-root contact in aeration slots
  - Saskatchewan
    - Low-fertility site: Injected manure increased yield
    - High-fertility site: injector damage decreased yield
    - Balance between nutrient response and mechanical damage

Application Methods for Alfalfa
Liquid Dairy Manure, Marshfield, WI

Treatments

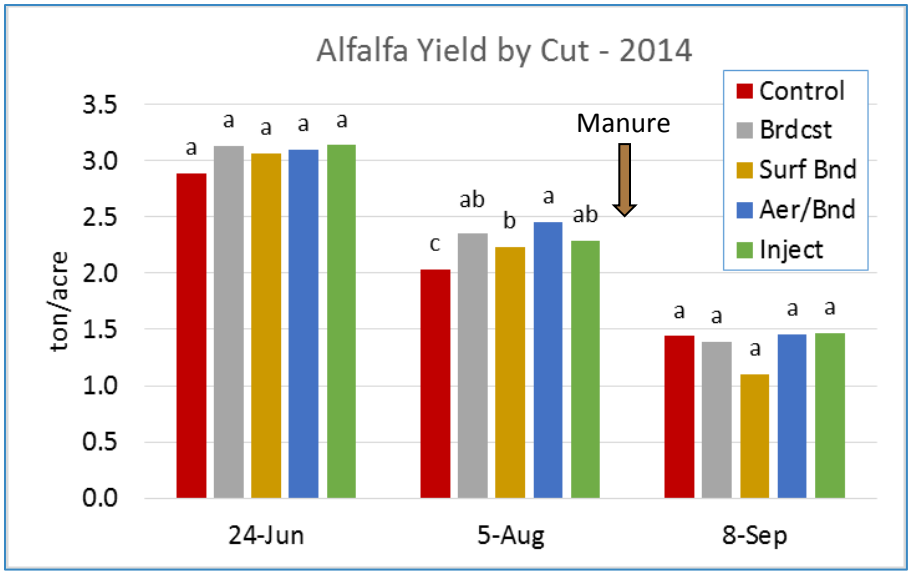
- Control (no manure; fertilized as needed)
- Broadcast manure
- Surface banded
- Aerator/banded manure (AerWay SSD)
- Shallow injection (Yetter Avenger)

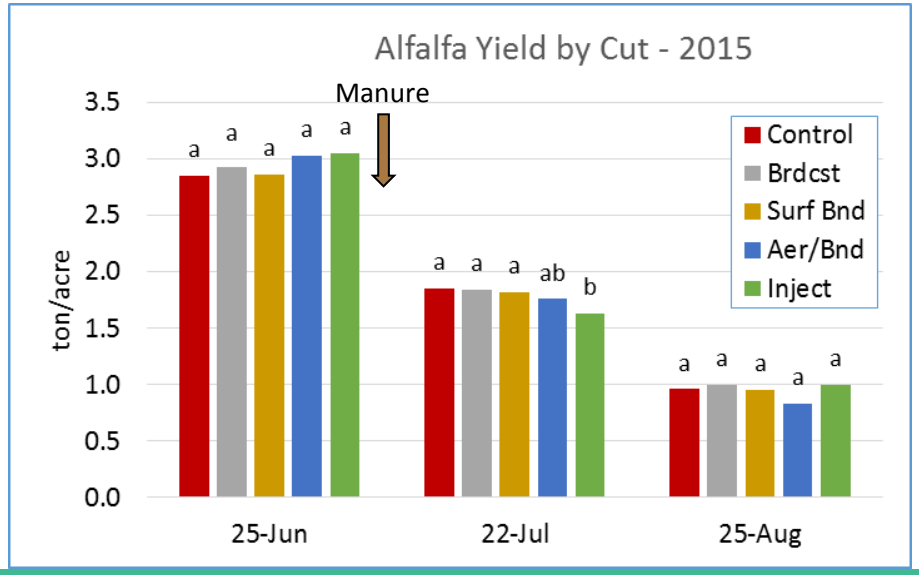
Measurements

- Yield and nutrient uptake
- Ammonia emission
- Greenhouse gas (N_2O) emission
- Runoff nutrient loss

Jokela et al.

Alfalfa Yield by Harvest





2014

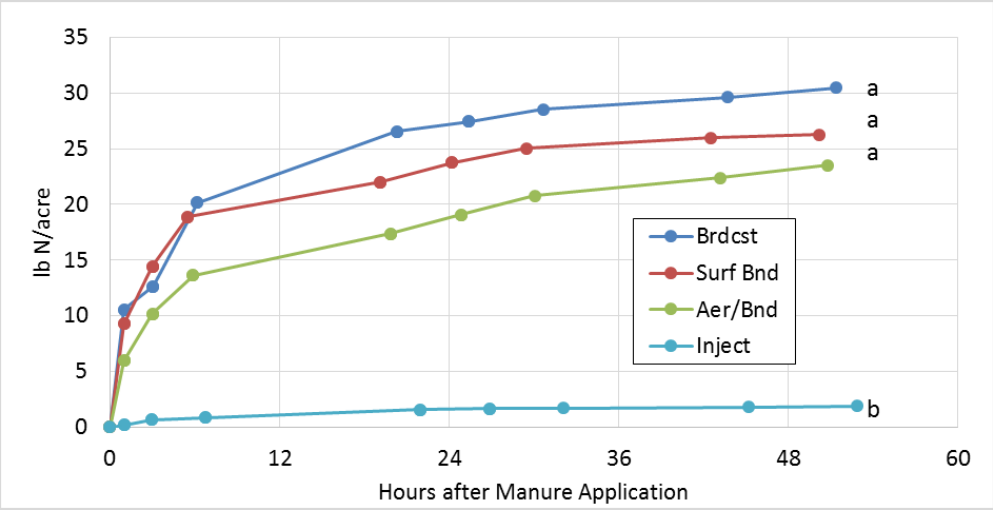
- No yield effects in first harvest after manure or next harvest (2015)

2015

- Lower yield from injection 1st harvest after manure, but not next harvest

Gaseous N Emission

Cumulative Ammonia N Loss - 2015



- Most of loss in first 8 hours
- Injection greatly reduced NH_3 loss (>95%) vs Broadcast
- Trend: Aerator-Band <Surface Band<Broadcast

Greenhouse Gas (N_2O) Emission - 2015

- Increased emission and treatment effects limited to 1-month post-manure period
- Greater emission from injection and aerator-band
  - Better conditions for denitrification
  - Less NH_3 loss, so more N available for denitrification

Preliminary Results: Summary

- Results of first 2 years of 3-year experiment
- Minimal effects of manure application on yield compared to the no-manure control (optimum or higher soil test P and K)
- Some indication of a short-term (one harvest) decrease in yield from the injection treatment.
- Injection greatly decreased ammonia emission, but there may be a trade-off with increased greenhouse gas (N_2O) emission.
- Nutrient runoff losses were quite variable; no consistent treatment effects (preliminary)

Recommendations for Pre-plant Manure Before Seeding

- Priority on low fertility soils
- Can apply to meet P and K needs (but avoid excess N)
- Limit rates to avoid high salt and NH_3 levels
- Till to mix thoroughly with soil to avoid manure-seed contact

Kelling and Schmitt, 2003; others

Recommendations for Manure Applications at Termination of Stand/Before Plowdown

- Limit to N need of succeeding crop (with legume credit)
- Apply to fields with poorest stands, least regrowth (lowest N credit)
- Apply immediately before tillage to minimize nutrient runoff loss potential
- Use Pre-sidedress Nitrate Test (PSNT) next year to assess N need for corn

Kelling and Schmitt, 2003

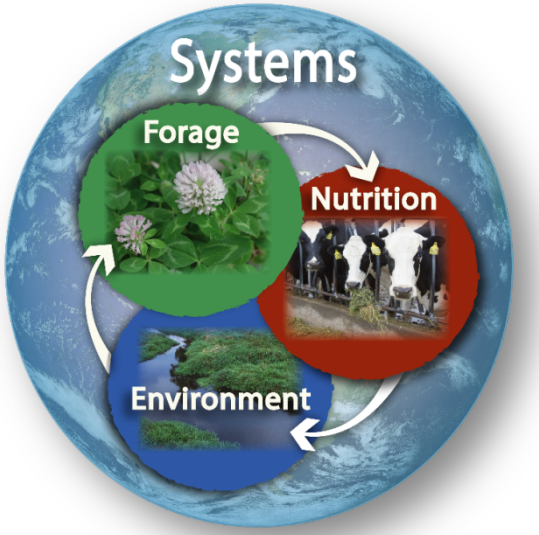
Recommendations for In-season Topdressed Manure Applications

- ***No serious disease in herd or manure***
- **Apply where nutrients needed**
  - Grass forages (N)
  - Low-fertility fields
- **Low-moderate rates**
- **As soon as possible after harvest**
- **Older stands of alfalfa; greater grass content**
- **Apply uniformly; no chunks**
- **Firm soils**
- **Consider alternatives to surface broadcast**

Kelling and Schmitt, 2003; M Russelle

QUESTIONS?

Leading the world in integrated dairy forage systems research.



U.S. Dairy Forage Research Center

www.ars.usda.gov/mwa/madison/dfrc