Properties of Manure as a Fertilizer for Forages

Anthony Fulford
Nutrient Management/Soil Quality Advisor

Alfalfa and Forage Field Day

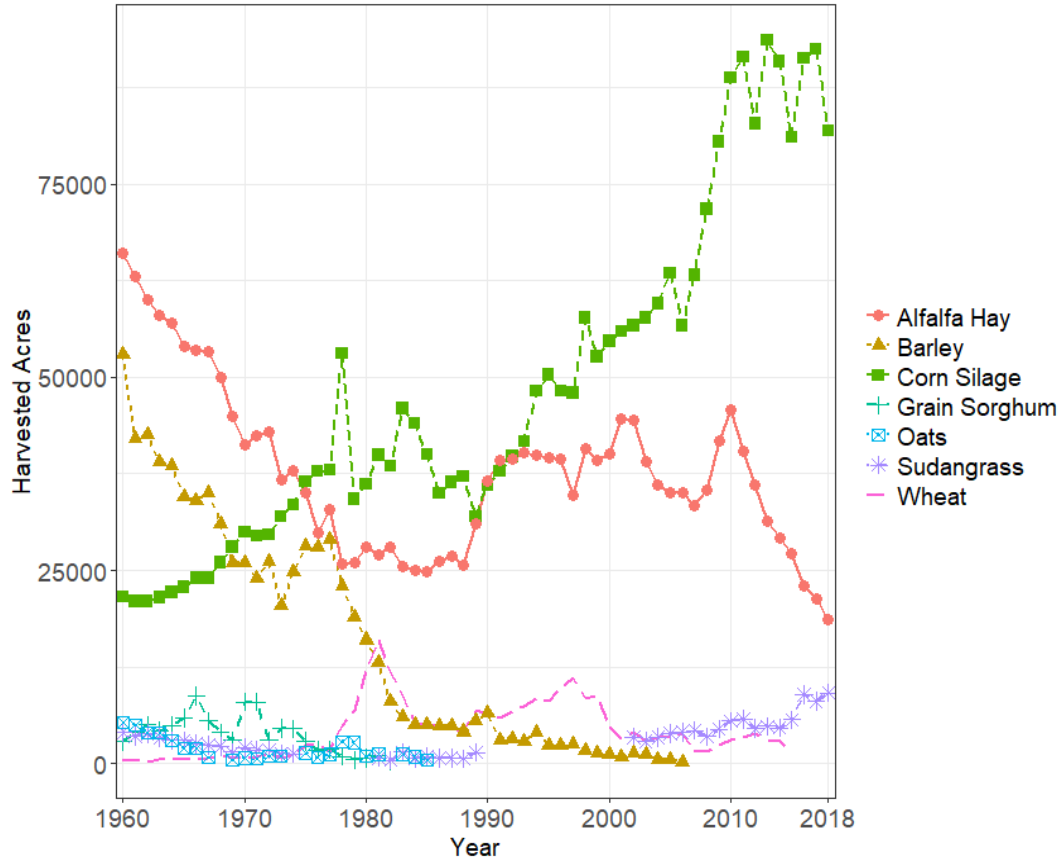
September 23, 2021

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Forage Crop Trends – Stanislaus Co.

- Historical Shifts in Crop Production (1960 to 2018)
  - Alfalfa declined on average 330 ac/yr
  - Corn silage increased on average 1170 ac/yr
  - Corn (24 T/ac) and alfalfa (7 T/ac)

- Top Commodities – Economic Value (2019)
  - Almonds (34%) – 1.2 billion
  - Milk (17%) – 630 million
  - Silage (4%) – 140 million



UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Forage Crop Nutrient Removal

- Corn silage – 24 T/ac @ 67% Moisture
  - N: 232 lbs/ac
  - P: 32 lbs/ac
  - K: 145 lbs/ac

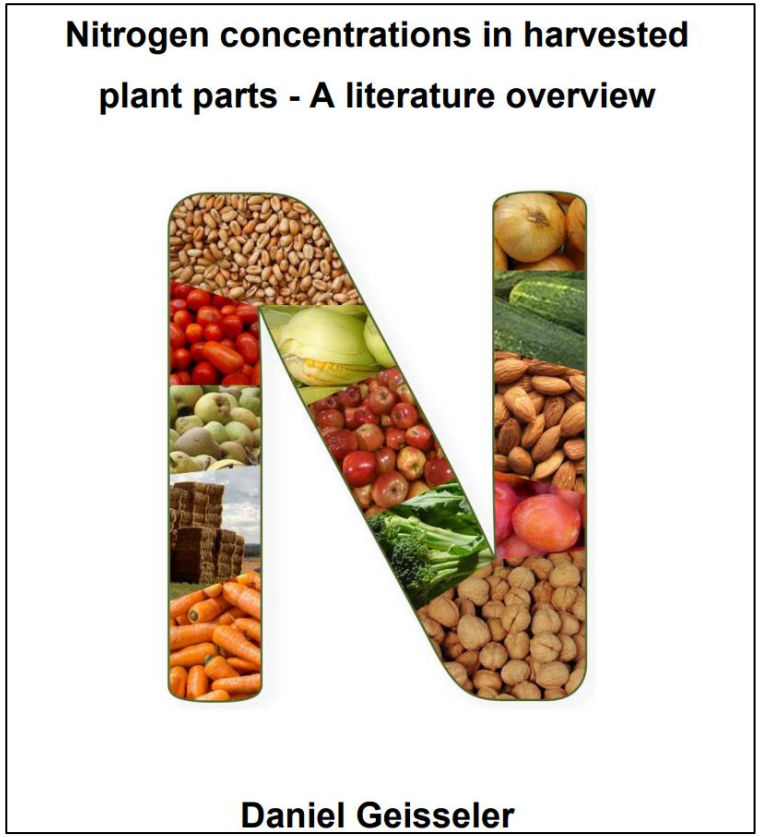
- Alfalfa – 7 T/ac @ DM Basis
  - N: 357 lbs/ac (N fixation)
  - P: 37 lbs/ac
  - K: 285 lbs/ac

Potassium Deficiency: Yellow or white spots on the margins of the leaflets

Source: IPNI Nutrient Removal Calculator

Meeting Nutrient Requirements

- Match Nutrient Addition to Crop Removal
  - “Book values” for nutrient removal rates
- Account for Nutrient Inputs and Outputs
  - Inputs: Fertilizer, irrigation, soil, and crop rotation credit
  - Outputs: Crop nutrient removal and off-site transport
- Appropriate for Initial Nutrient Management Plans
  - Adjustments needed to refine nutrient budget



Nitrogen Reporting Requirements

- Irrigated Lands Regulatory Program (2003)
  - Groundwater regulations added (2012)
- Central Valley Water Quality Coalitions
  - Work directly with growers/members
  - Water quality monitoring
  - Meet reporting requirements
- Irrigation and N Management Plan Worksheet
  - Minimize N loss to surface and groundwater
  - Meet crop N needs
    - Including organic amendments

IRRIGATION MANAGEMENT

1. Irrigation Method* (check one for Primary; if applicable, check one for Secondary)	Pre-Season Planning	
Primary / Secondary[1]: ☐ Drip; ☐ Micro Sprinkler; ☐ Furrow; ☐ Sprinkler; ☐ Border Strip; ☐ Flood	2. Crop Evapotranspiration (ET, inches)	
	3. Anticipated Crop Irrigation (inches)	
	4. Irrigation Water N Concentration (ppm or mg/L, as NO_3-N)	

5. Irrigation Efficiency Practices* (Check all that apply)

- ☐ Laser Leveling
- ☐ Use of ET in scheduling irrigations
- ☐ Water application schedule to need
- ☐ Use of moisture probe (e.g. tensiometer)
- ☐ Soil Moisture Neutron Probe
- ☐ Pressure Bomb
- ☐ Other _____
- ☐ Other _____

HARVEST / YIELD INFORMATION

Harvest / Yield Information		Expected (A)	Actual (B)
6. Production Unit (lbs, tons, etc.)	7. Harvested Yield*		

NITROGEN MANAGEMENT

8. Nitrogen Efficiency Practices* (Check all that apply)	Nitrogen Sources	Recommended/ Planned N (A)	Actual N (B)
☐ Split Fertilizer Applications ☐ Irrigation Water N Testing ☐ Soil Testing ☐ Tissue/Petiole Testing ☐ Fertigation ☐ Foliar N Application ☐ Cover Crops ☐ Variable Rate Applications using GPS ☐ Other: _____ ☐ Other: _____	9. Soil – Available N in Root Zone (Annualized, lbs/ac)		
	10. N in Irrigation Water* (Annualized, lbs/ac)		
	11. Organic Amendments* (Manure/Compost/Other, lbs/ac estimate)		
	12. Dry/Liquid Fertilizer N* (lbs/ac)		
	13. Foliar Fertilizer N* (lbs/ac)		
	14. TOTAL NITROGEN (lbs/ac)		

waterboards.ca.gov

Meeting Nutrient Requirements - Manure

- Manure is a Valuable Source of Plant Nutrients
  - But there is no guaranteed nutrient content, testing is critical!
  - Timing of nutrient availability, especially nitrogen, difficult to estimate

- Manure is More Than a Nutrient Source
  - Carbon additions help build soil tilth and health
  - Bedding material inclusion can also add organic matter to soils

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Manure as a Fertilizer Source

- Challenges to using manure as a fertilizer source – handling, storage and application method

Handling/Storage or Application Method (solids)	Nitrogen Loss, %
Daily Scrape & Haul	13 – 35
Manure Pack	20 – 40
Open Lot	40 – 60
Broadcast w/out Incorporation	15 – 30
Broadcast w/ Incorporation	1 – 5

Source: Sutton et al., 1983

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Manure as a Fertilizer Source

- Challenge to using manure as a fertilizer source – not all N present is immediately available to the crop

Manure Type	Year 1, Nmin %	Year 2, Nmin %
Dairy Lagoon Water	40 – 50	15
Dairy Lagoon Sludge/Slurry; Corral	20 – 30	15
Dairy Mechanical Screen Solids	10 – 20	5

Source: Pettygrove, Heinrich, and Crohn, 2009

- Year 2 N mineralization can result in a manure “credit” to be used in future N budget

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Physical Properties of Manure

- Solids Fraction Remains After Water is Removed
  - Directly influences nutrient content, treatment processing, and handling

- Total Solids Reveal Physical Composition of Liquid or Slurry
  - Determine inorganic and organic solids composition
  - TS (Total) = FS (Fixed) + VS (Volatile)
  - Fixed solids remain after heating at 550C for 1h
    - No nutrient value, influences processing, and added weight
  - Volatile solids are lost after heating
    - Represent the organic matter content of liquid or slurry

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Chemical Properties of Manure

- Chemical composition includes macro, secondary, and micronutrients
  - Characterization helps identify how nutrient levels impact crop productivity
- Chemical analysis reveals inorganic and organic nutrients
  - Inorganic N as ammonium and nitrate (immediately available)
  - Total Kjeldahl Nitrogen (TKN) = ammonium N + organic N
  - TKN - ammonium = organic N
- Manure is a heterogeneous fertilizer product
  - Application to meet crop N requirements results in overapplication of P
  - Composting, bedding additions, animal diet, seasonal changes

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Characterization of Dairy Manure

California Dairy Research Foundation Project (2020 – 2021)

Nick Clark, Anthony Fulford, Joy Hollingsworth, and Deanne Meyer

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Characterization of Dairy Manure

- Goal is to better characterize physical and chemical composition of dairy manure

- Manure sampled from liquid, slurry, and solids waste streams
  - Temperature and pH obtained immediately
  - Physical and chemical properties evaluated in the laboratory

- Dairies were categorized based on manure management system
  - Vacuum, solids separation, anaerobic digesters, and other approaches

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Objective

- Identify the physical and chemical composition of manure from 20 Central Valley dairies
  - Vacuum (4 Dairies) – preliminary results presented today
  - Compost Bedded Pack (3 Dairies)
  - Anaerobic Digester (8 Dairies)
  - ‘Other’ (5 Dairies)

- Manure collection occurred twice at each dairy
  - Characterize variability in physical and chemical composition
  - Examine compositional changes with seasons (cold vs. warm)

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Preliminary Results Summary

- Physical composition (solids fraction) of vacuum manure differed by dairy but largely unchanged by season (cold vs. warm)

- Fraction of inorganic ammonium N was noticeably different among dairies and tended to be much lower in warm season
  - Observed decrease of inorganic N relative to organic N when sampling in warm season

- Total K and Ca of manure noticeably varied w/in and among dairies and trend was consistent between seasons
  - However, P and Na exhibited very small differences among dairies or seasons

Acknowledgements

- Central Valley Dairy Operators/Collaborators
- California Dairy Research Foundation
- Jennifer Heguy, Madeline Morataya, Chaitanya Muraka, Joyce Pexton, Benjamin Halleck