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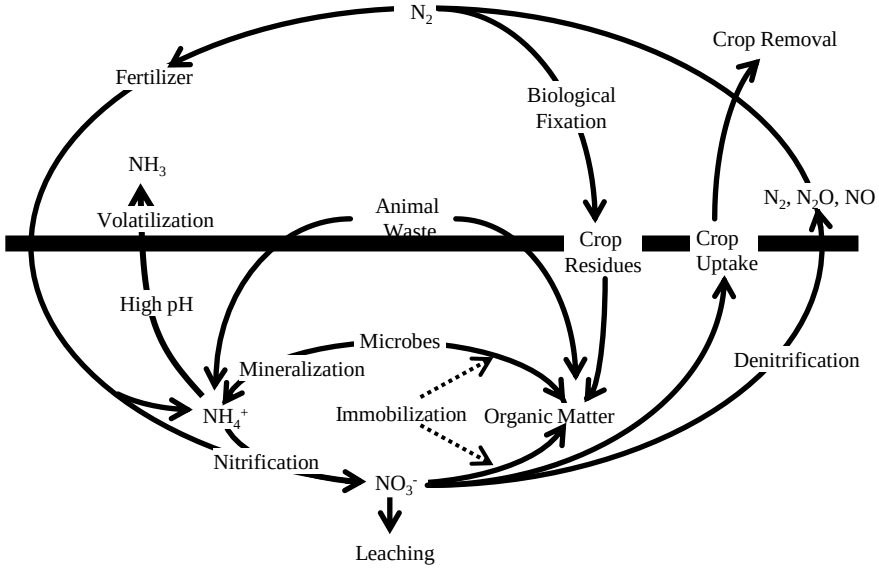
A NEW VISION FOR NITROGEN MANAGEMENT

Penn State **Extension**

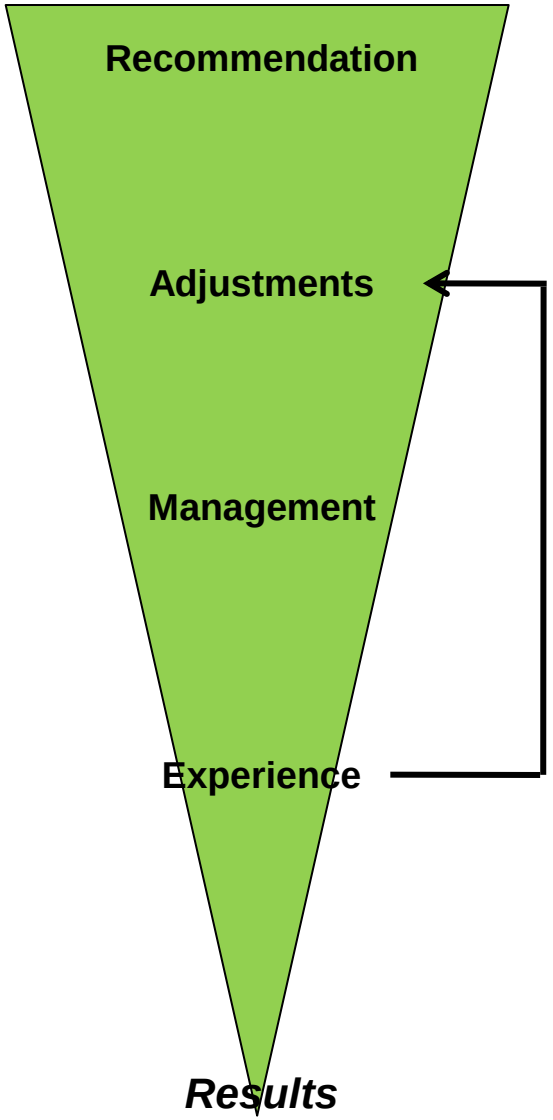
Real World N Management It's Tough!

- Very complex
- Very leaky
- Dependent on weather
- We understand N behavior but it is very difficult to predict usefully
- **N Recommendations are a process not an answer**



N Management Process

- Recommendations
  - Crude, but hopefully educated guesses
  - Get us started in the ballpark
- Adjustments
  - Rough estimates
    - Legumes
    - Manure
  - Refine the guesses
    - PSNT or Chlorophyll Meter
- Management
  - Source, method and timing of application
- Experience
  - N Management is a series of successive approximations
    - Late Season Stalk Nitrate Test
    - Check strips
  - Records



Nitrogen Recommendations

- There is no soil test for routine N recommendations
- Standard fertilizer N recommendations are usually based on crop and expected yield
  - Ex. Corn 1 lb N/bu expected yield
- Recommendations generally already have a safety buffer built in
  - Don’t exceed recommended rates
- **Don’t count on N recommendations as the final answer**

Nitrogen Recommendations

Nitrogen recommendations for agronomic crops. (Table 1.2-6, Penn State Agronomy Guide)

Crop	Recommendation (lb N/unit of expected yield)	Comments
Corn grain	1	For better N efficiency, delay application of the nitrogen until the corn is between 10 and 20 inches tall. If the field has a history of manure and/or legumes, delay all of the N. If there is no history of manure and/or legumes, split the N, applying one-third near to planting and delaying the balance. Adjust this recommendation for any previous legume in the rotation (see Table 1.2-8) and for residual N from previous manure applications (see Tables 1.2-14 or 1.2-15). The PSNT or chlorophyll meter test can be used to refine N recommendations for corn, especially where manure is a major nutrient source.
Corn silage	7	For better N efficiency, delay application of the nitrogen until the corn is between 10 and 20 inches tall. If the field has a history of manure and/or legumes, delay all of the N. If there is no history of manure and/or legumes, split the N, applying one-third near to planting and delaying the balance. Adjust this recommendation for any previous legume in the rotation (see Table 1.2-8) and for residual N from previous manure applications (see Tables 1.2-14 or 1.2-15). The PSNT or chlorophyll meter test can be used to refine N recommendations for corn, especially where manure is a major nutrient source.
Grain sorghum	0.75	Adjust this recommendation for any previous legume in the rotation (see Table 1.2-8) and for residual N from previous manure applications (see Tables 1.2-14 or 1.2-15).
Forage sorghum	7	Adjust this recommendation for any previous legume in the rotation (see Table 1.2-8) and for residual N from previous manure applications (see Tables 1.2-14 or 1.2-15).
Oats	0.8	Apply the N with any other fertilizer before planting. Adjust this recommendation for any residual N from previous manure applications (see Tables 1.2-14 or 1.2-15).
Wheat/Rye	1.0	If plants did not tiller well, apply N by mid-March; otherwise, apply any time up to growth stage 5. Adjust this recommendation for any residual N from previous manure applications (see Tables 1.2-14 or 1.2-15).
Barley	0.8	If plants did not tiller well, apply N by mid-March; otherwise, apply any time up to growth stage 5. Adjust this recommendation for any residual N from previous manure applications (see Tables 1.2-14 or 1.2-15).
Small grain silage	17	Apply at greenup in the spring.
Grass hay	50	Split the nitrogen recommendation and apply it based on the expected yield for each cutting. For grass-legume mixtures, if the legume is more than 50% of the stand, the field should be managed as a legume; thus, no nitrogen is recommended. Adjust this recommendation for any residual N from previous manure applications (see Tables 1.2-14 or 1.2-15).

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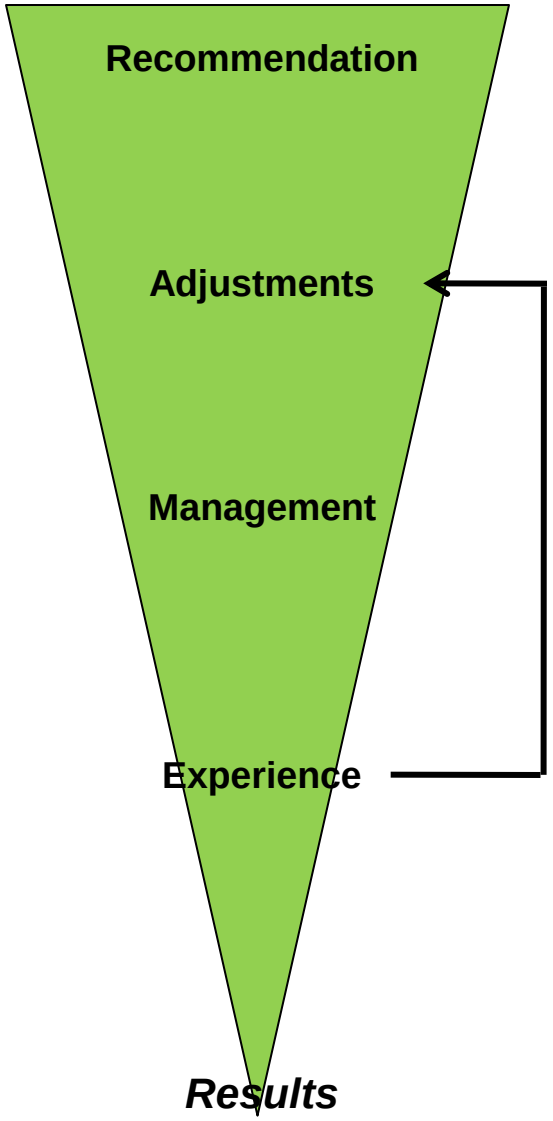
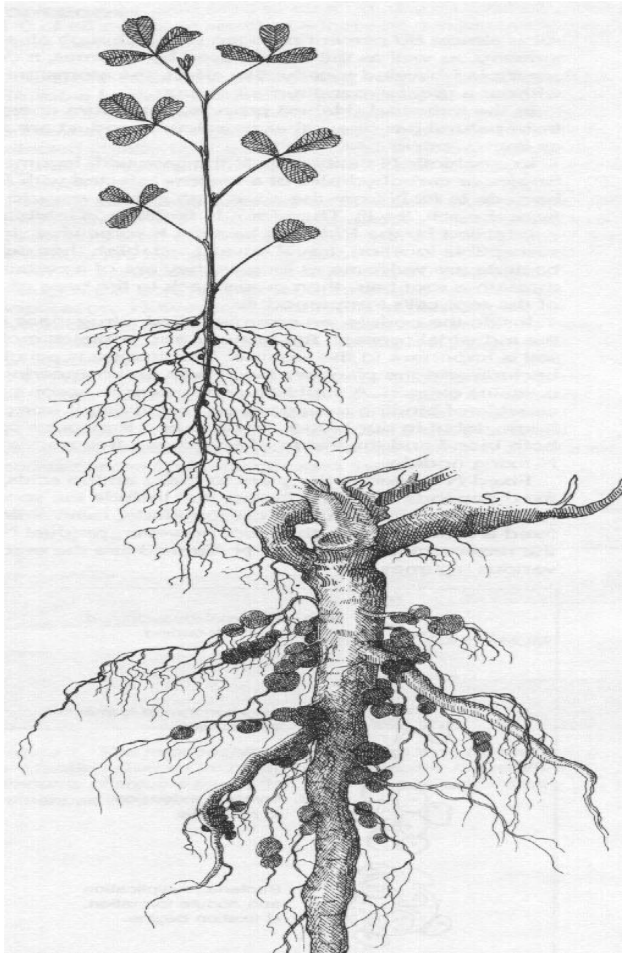


Residual Legume N

- Properly inoculated legumes meet their N requirement by fixing atmospheric N.
- Significant N remains in residue from legume when crops are rotated.
- Adjust following crop for N credit



Alfalfa

Soybean

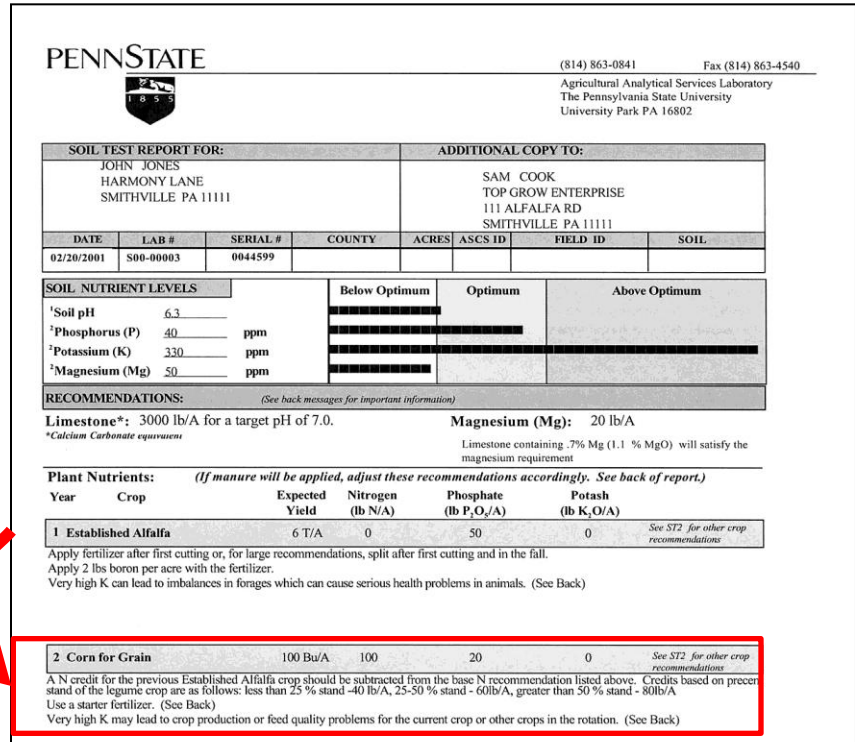
Legume N

Residual N from Legumes (PSU Agronomy Guide Table 1.2-8)

Table 1.2-8. Residual nitrogen contributions from legumes for corn production.

Previous crop	% Stand	Soil Productivity Group: Group 1	Groups 2 & 3	Groups 4 & 5
Alfalfa		Nitrogen Credit (lb/A)		
	First year after alfalfa			
	>50% stand	120	110	80
	25%-49% stand	80	70	60
	<25% stand	40	40	40
	Second year after alfalfa			
	>50% stand	60	60	60
Red clover and trefoil				
	First year after clover or trefoil			
	>50% stand	90	80	60
	25%-49% stand	60	60	50
	<25% stand	40	40	40
Soybeans				
	First year after soybeans harvested for grain	- - - - - - - - - 1 lb N/bu soybeans - - - - - - - -		

PSU Soil Test: Residual N Previous Legume Crops



PENNSTATE

(814) 863-0841 Fax (814) 863-4540

Agricultural Analytical Services Laboratory
The Pennsylvania State University
University Park PA 16802

SOIL TEST REPORT FOR:	ADDITIONAL COPY TO:
JOHN JONES HARMONY LANE SMITHVILLE PA 11111	SAM COOK TOP GROW ENTERPRISE 111 ALFALFA RD SMITHVILLE PA 11111

DATE	LAB #	SERIAL #	COUNTY	ACRES	ASCS ID	FIELD ID	SOIL
02/20/2001	S00-00003	0044599					

SOIL NUTRIENT LEVELS			Below Optimum	Optimum	Above Optimum
[1]Soil pH	6.3				
[2]Phosphorus (P)	40	ppm			
[2]Potassium (K)	330	ppm			
[2]Magnesium (Mg)	50	ppm			

RECOMMENDATIONS: *(See back messages for important information)*

Limestone*: 3000 lb/A for a target pH of 7.0.
**Calcium Carbonate equivalent*

Magnesium (Mg): 20 lb/A
Limestone containing .7% Mg (1.1 % MgO) will satisfy the magnesium requirement

Plant Nutrients: *(If manure will be applied, adjust these recommendations accordingly. See back of report.)*

Year	Crop	Expected Yield	Nitrogen (lb N/A)	Phosphate (lb P_2O_5/A)	Potash (lb K_2O/A)	
1	Established Alfalfa	6 T/A	0	50	0	*See ST2 for other crop recommendations*

Apply fertilizer after first cutting or, for large recommendations, split after first cutting and in the fall.
Apply 2 lbs boron per acre with the fertilizer.
Very high K can lead to imbalances in forages which can cause serious health problems in animals. (See Back)

2 **Corn for Grain**	100 Bu/A	100	20	0	*See ST2 for other crop recommendations*

A N credit for the previous Established Alfalfa crop should be subtracted from the base N recommendation listed above. Credits based on precent stand of the legume crop are as follows: less than 25 % stand -40 lb/A, 25-50 % stand - 60lb/A, greater than 50 % stand - 80lb/A
Use a starter fertilizer. (See Back)
Very high K may lead to crop production or feed quality problems for the current crop or other crops in the rotation. (See Back)

Agronomy

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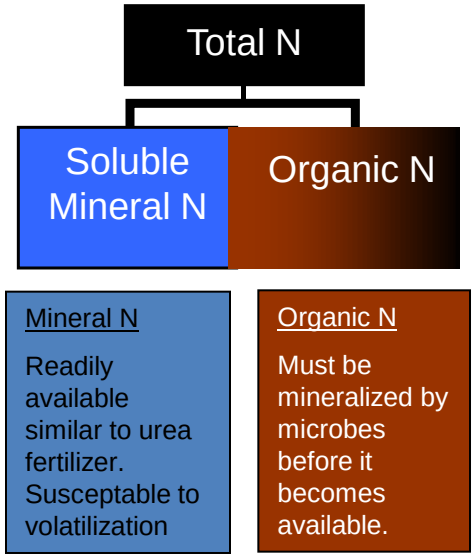
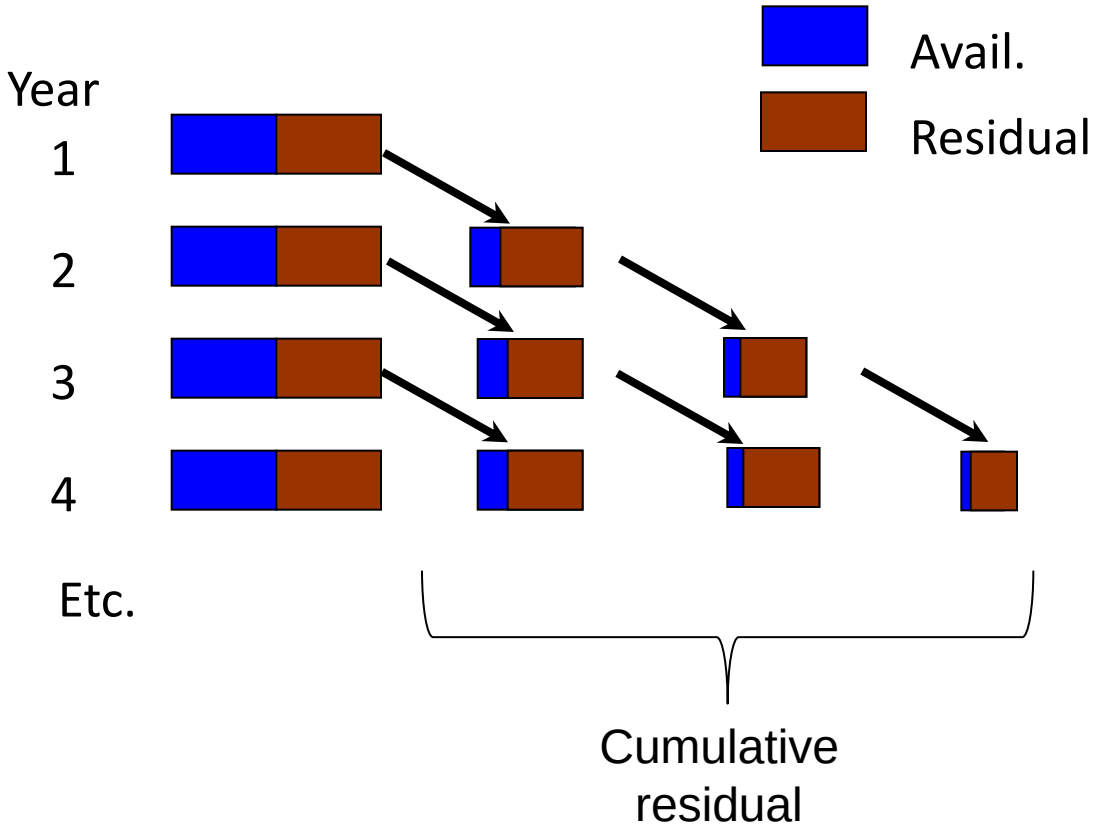
A N credit for the previous Established Alfalfa crop should be subtracted from the base N recommendation listed above. Credits based on precent stand of the legume crop are as follows: less than 25 % stand -40 lb/A, 25-50 % stand - 60lb/A, greater than 50 % stand - 80lb/A
Use a starter fertilizer. (See Back)
Very high K may lead to crop production or feed quality problems for the current crop or other crops in the rotation. (See Back)

Residual N from Manure





Residual N from past manure application

Agronomy Guide Table 1.2-14	*Residual N (lb N/A)*
Rarely received manure in the past (< 2 out of 5 yrs)	0
Frequently received manure (2 - 3 out of 5 yrs)	20
Continuously received manure (4 - 5 out of 5 yrs)	35

Table 1.2-15. Factors for calculating manure nitrogen availability based on time of application, incorporation, field history, and manure analysis with ammonium and organic N fractions. Recommended for all manures, but required for atypical or treated manures.

TOTAL MANURE N

AMMONIUM N ANALYSIS

Spring/summer

For spring utilization by small grains and grass hay and summer utilization by corn, other summer annuals, and grass hay

Days to incorp.[1]	Poultry[2]	Other[2]	Compost
Immediately	0.90	0.80	0.80
1	0.80	0.60	0.60
2–4	0.60	0.40	0.40
5–7	0.40	0.20	0.20
>7	0.20	0.10	0.10

Early Fall

For fall and spring use by grass hay and small grains

Days to incorp.[1]	Poultry[2]	Other[2]	Compost
0–2	0.50	0.40	0.40
3–7	0.25	0.20	0.20
>7	0	0	0

For following summer utilization by corn or other summer annuals

All	0	0	0

Late fall/winter

Days to incorp.[1]	Poultry[2]	Other	Compost

For summer use by corn or summer annuals with no cover crop or cover crop harvested for silage

All	0	0	0

For spring use by grass hay or small grains, or summer use by corn or summer annuals with green manure cover crop

N/A	0.60	0.50	0.50

1. Mechanical incorporation or incorporation by 0.5 inch of rain.
2. Increase these factors by 0.2 after one day for very liquid manures (<5 percent solids) to account for soaking-in on application.

ORGANIC N ANALYSIS (total N – ammonium N)

Organic N decomposed during year applied

Dry matter	Poultry	Swine	Other	Compost
<18%	0.60	0.50	0.35	0.10
>18%	0.60	0.50	0.25	0.10

Organic N decomposed from past applications

Manure applied	Manure	Compost
1 yr ago	0.12	0.05
2 yrs ago	0.05	0.02
3 yrs ago	0.02	0.01
4 yrs ago	0.02	0.01
5 yrs ago	0.01	0.01

Adapted from Klausner and Bouldin, Cornell University; Jokela, University of Vermont; and Sims, University of Delaware.

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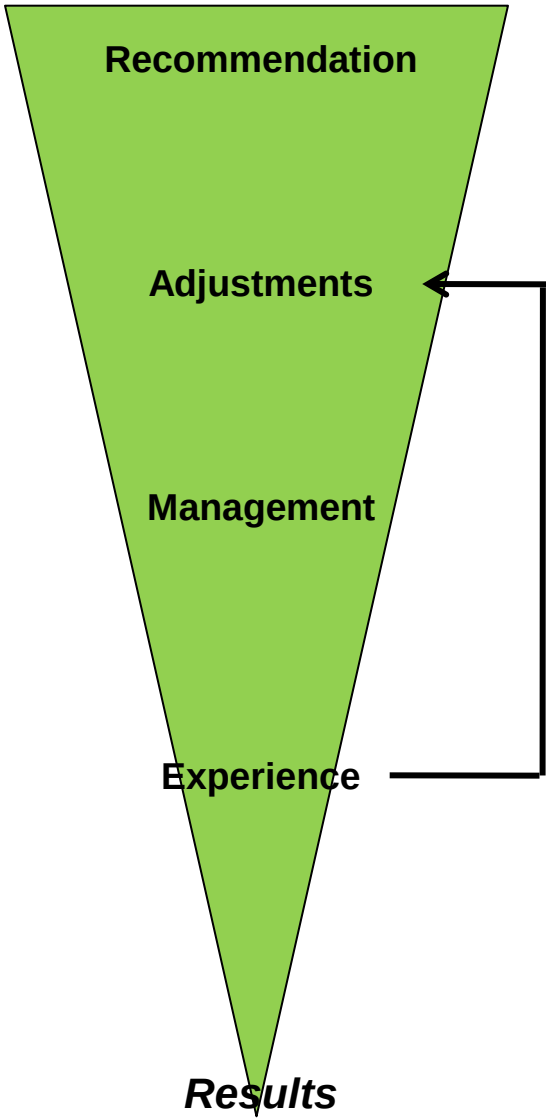


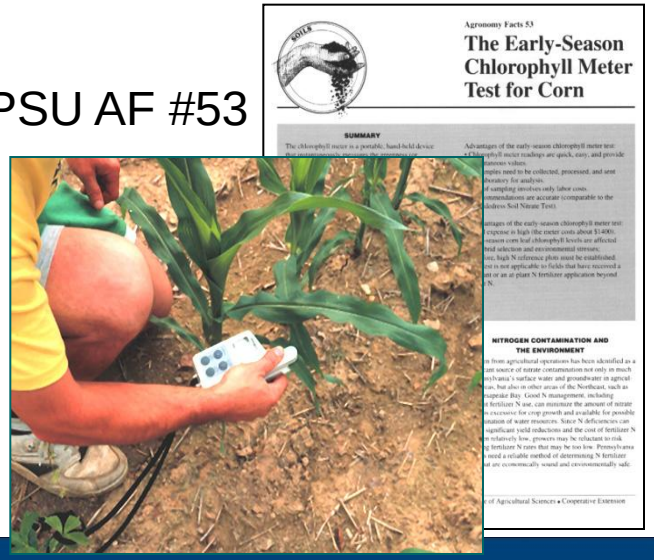
Tools for Adjusting N Management

- In-season Pre-sidedress Tests for Corn
  - Pre-sidedress Soil Nitrate Test for Corn (PSNT)
  - Chlorophyll Meter Test
- In-season tests ~12” tall corn
  - Requires sidedressing N
- Very good a predicting whether there will be a response to sidedress N
  - Eliminates insurance N
- “Improved” recommendations especially in manured systems

  Sidedress N recommendation with these tests are about twice as accurate as without the tests

PSU AF #17

PSU AF #53



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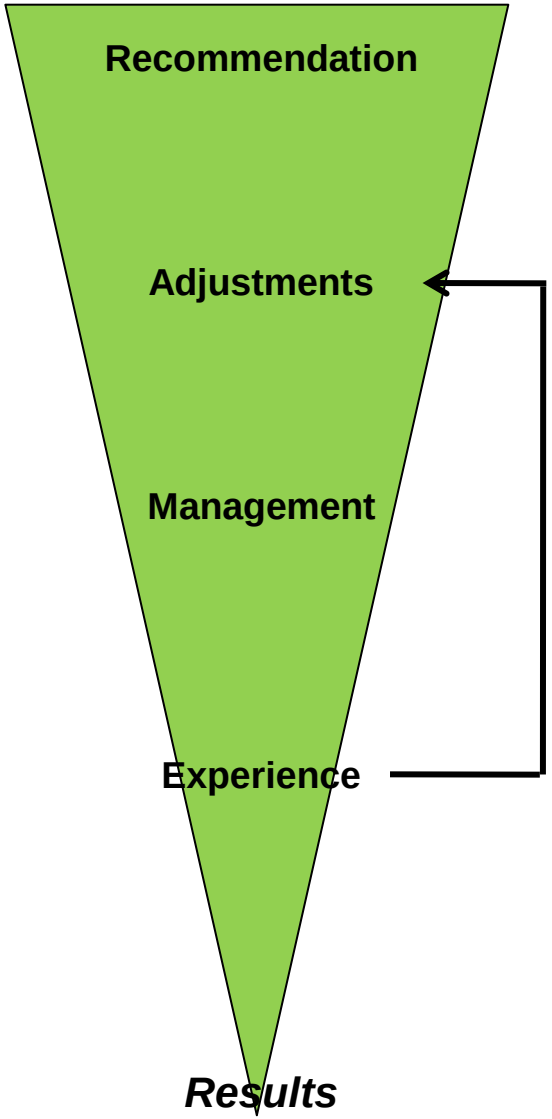

Nitrogen Sources

- Fertilizer materials
  - Urea (46-0-0)
    - *Solid, Volatile*
  - UAN (30-0-0)
    - *Fluid, Volatile*
  - Ammonium Sulfate (21-0-0-24S)
    - *Solid, Non-volatile*
  - Ammonium Nitrate (33-0-0)
    - *Solid, Non-volatile, Handling*
  - Anhydrous Ammonia (82-0-0)
    - *Gas, Incorporated, Handling*
  - MAP (11-52-0)
    - *Solid, multinutrient*
  - DAP (18-46-0)
    - *Solid, multinutrient*
  - Poly N (10-34-0)
    - *Fluid, multinutrient*

Agronomy Guide Table 1.2-11. Description of fertilizer materials.

Table 1.2-11. Description of fertilizer materials.

Fertilizer	Total N, %	Available phosphoric acid, %	Soluable potash, %	Equivalent acidity [1]	Salt index [2]	Comments
Anhydrous ammonia—NH_3	82	0	0	148	47	A high-pressure liquid that turns into a gas when released. Must be injected 6–8 inches deep on friable, moist soil. N loss by volatilization can occur if not properly injected, or if soil is too wet or too dry at application.
Urea—NH_2-CO-NH_2	46	0	0	84	75	A dry material in granular or prilled form, urea-N rapidly hydrolyzes to NH_4^+. Can be used for direct application, in mixed fertilizers, and in liquid nitrogen. N at application is present as urea-N. Within 1 day after application, about 66% of urea-N is hydrolyzed to ammonia-N; all within 1 week. When not incorporated, significant N loss by volatilization can occur until approximately 0.5 inch of rain has fallen. Not recommended for starter use. Broadcast (incorporated) or sidedress.
Ammonium nitrate—NH_4NO_3	33–34	0	0	63	105	A dry material in granular or prilled form, in which half of the N is as nitrate and half is as ammonium. Used for direct application and in the production of nitrogen solutions (see below). Broadcast or sidedress. Can be left on surface or incorporated into soil. Ammonium nitrate is a good fertilizer but it can be very difficult to get because it is used as an explosive.
Nitrogen solutions (UAN)—Urea+NH_4NO_3+Water	28–32 (mostly 30 in	0	0	54	74	A mixture of ammonium nitrate, urea, and water. Urea supplies about half of the N that may be subject to volatilization loss—read comments above for urea. The other half of N is supplied by ammonium nitrate—read comments above for ammonium nitrate. Once applied, nitrogen solution behaves exactly like dry urea and ammonium nitrate. To minimize N loss, incorporate into soil as soon as possible after application. Use caution when spraying, as leaf burn can occur. To minimize injury, do not spray on vegetation. For postemergence application, use a directed spray or dribble between the rows.
Ammonium sulfate—$(NH_4)_2SO_4$	21	0	0	112	69	A dry crystalline material in which the nitrogen is all in the ammonium form. Produced by two methods—by-product and synthetic. Used for direct application and blended complete fertilizers. Broadcast or sidedress. Can be left on surface or incorporated into soil. Contains 24% sulfur. Good starter N source.
Diammonium phosphate (DAP)—$(NH_4)_2HPO_4$	18	46	0	74	34	A dry granular or crystalline material. Common analysis is 18-46-0. Used for direct application and in blended fertilizers. Starter fertilizers containing DAP should be used with caution; be sure to band at least 2 inches to the side and 2 inches below seed.
Monoammonium phosphate (MAP)—$NH_4H_2PO_4$	11	52	0	65	30	A dry granular material. Common analysis 11-52-0. Used for direct application and in blended fertilizers. Makes an excellent starter fertilizer, either alone or with a small amount of potash.
Ammonium polyphosphate	10	34	0	53	-	A liquid solution (10-34-0). The agronomic effectiveness of APP is similar to that of MAP. Sequesters some micronutrients and impurities in fluid fertilizers, keeping them in solution.
Triple superphosphate—$Ca(H_2PO_4)_2$	0	46	0	0	10	Dry granular material. Used for direct application and in blended fertilizers.
Muriate of potash—KCl	0	0	60–62	0	116	Dry granular material. Used for direct application and in blended fertilizers.
Potassium sulfate—K2SO4	0	0	50	0	46	Dry crystalline material. A specialty fertilizer used for direct application and in blended fertilizers.
Potassium nitrate—KNO_3	13	0	45	-26	74	Dry crystalline material. A specialty fertilizer used for direct application and in blended fertilizers.
Potassium hydroxide—KOH	0	0	70	-89	-	Crystalline material usually used in liquid fertilizers. Basic nature of this material allows production of neutral liquid fertilizers. Primarily used in liquid starter fertilizers.
Sulfate of potash magnesia— Sul-Po-Mag or K-Mag	0	0	22	-	-	Crystalline material made from langbeinite. Contains 22% sulfur and 11% magnesium.

1. Pounds of calcium carbonate equivalent/100 lb of fertilizer material. Positive numbers indicate that the material increases soil acidity, that is, lowers soil pH. Negative numbers indicate that the material reduces acidity, that is, raises soil pH.

2. Salt index of equal weights of the fertilizer material compared to sodium nitrate, which equals 100. Useful for comparing the salt effect of different fertilizer materials.

Nitrogen Sources

- Fertilizer materials
  - Urea (46-0-0)
    - *Solid, Volatile*
  - UAN (30-0-0)
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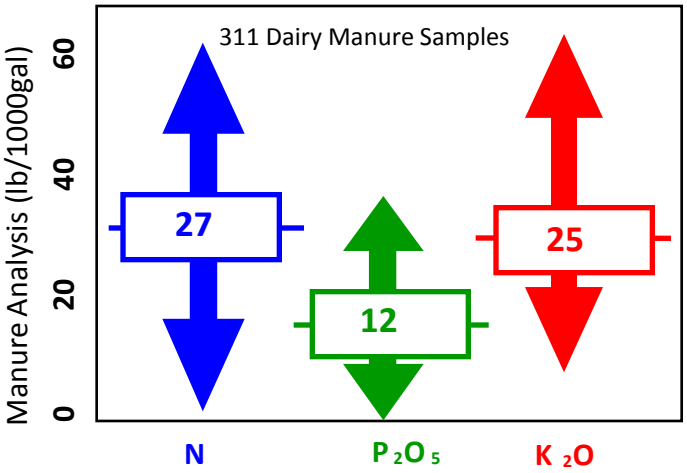
  - Ammonium Nitrate (33-0-0)
    - *Solid, Non-volatile, Handling*
  - Anhydrous Ammonia (82-0-0)
    - *Gas, Incorporated, Handling*

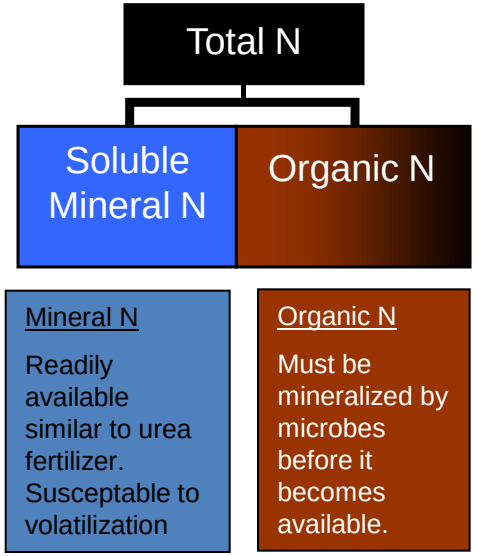
- Additives
  - ***Urease inhibitors***
    - Agrotain
    - Limit volatilization from surface applied urea containing fertilizers
  - ***Nitrification inhibitors***
    - N Serve, Instinct, DCD, Guardian
    - Limit leaching and denitrification from ammonium fertilizers applied a long time ahead of crop need ,especially on poorly drained or excessively well drains soils
  - *Controlled Release*
    - ESN
    - Spreads out the exposure to loss by controlled release

Manure N

- Manure Analysis
  - Manures, biosolids, composts, etc.
  - Book values good averages but worthless on any individual farm ± 100%



- Manure nutrient availability
  - N depends on handling
    - Timing & Incorporation
    - Cover crops
  - P and K similar to fertilizer



Manure Nitrogen Fertilizer Equivalent Based on Total N - AG Table 1.2-14

Planned Manure Application Season	Planned Manure Target Crop Utilization	Application Management	Nitrogen Availability Factor[1]		
			Poultry Manure	Swine Manure	Other Manure
Spring or Summer	Spring utilization by grass hay and small grains Summer utilization by corn, other summer annuals and grass hay Summer utilization by grass hay	Incorporation the same day Incorporation within 1 day Incorporation within 2-4 days Incorporation within 5-7 days Incorporation after 7 days or no incorporation	0.75 0.50 0.45 0.30 0.15	0.70 0.60 0.40 0.30 0.20	0.50 0.40 0.35 0.30 0.20
Early Fall[2]	Fall and spring utilization by grass hay and small grains	Incorporation within 2 days Incorporation within 3-7 days Incorporation after 7 days or no incorporation	0.50 0.30 0.15	0.45 0.30 0.20	0.40 0.30 0.20
	Following summer utilization by corn or other summer annuals	All situations	0.15	0.20	0.20
Late Fall or Winter[3]	Spring utilization by small grains and grass hay	All situations	0.50	0.45	0.40
	Following summer utilization by corn or other summer annuals	No cover crop Cover crop harvested for silage Cover crop used as green manure	0.15 0.15 0.50	0.20 0.20 0.45	0.20 0.20 0.40
Grazing	Late spring through early fall grazing	Manure deposited more less continuously by grazing cattle	-	-	0.20
	Year round grazing	Manure deposited more less continuously by grazing cattle	-	-	0.30

Manure Nitrogen Fertilizer Equivalence

Penn State Agronomy Guide Table 1.2-15 with example calculation

- **Treated manure**
- **Works for all manure**

Based on:

- More detailed analysis
  - NH_4-N & Organic N
- Application timing
- Application management
- Type of manure

Table 1.2-15. Factors for calculating manure nitrogen availability based on time of application, incorporation, field history, and manure analysis with ammonium and organic N fractions. Recommended for all manures, but required for atypical or treated manures.

TOTAL MANURE N

AMMONIUM N ANALYSIS

Spring/summer

For spring utilization by small grains and grass hay and summer utilization by corn, other summer annuals, and grass hay

Days to incorp.[1]	Poultry[2]	Other[2]	Compost
Immediately	0.90	0.80	0.80
1	0.80	0.60	0.60
2–4	0.60	0.40	0.40
5–7	0.40	0.20	0.20
>7	0.20	0.10	0.10

Early Fall

For fall and spring use by grass hay and small grains

Days to incorp.[1]	Poultry[2]	Other[2]	Compost
0–2	0.50	0.40	0.40
3–7	0.25	0.20	0.20
>7	0	0	0

For following summer utilization by corn or other summer annuals

All	0	0	0

Late fall/winter

Days to incorp.[1]	Poultry[2]	Other	Compost

For summer use by corn or summer annuals with no cover crop or cover crop harvested for silage

All	0	0	0

For spring use by grass hay or small grains, or summer use by corn or summer annuals with green manure cover crop

N/A	0.60	0.50	0.50

1. Mechanical incorporation or incorporation by 0.5 inch of rain.
2. Increase these factors by 0.2 after one day for very liquid manures (<5 percent solids) to account for soaking-in on application.

ORGANIC N ANALYSIS (total N – ammonium N)

Organic N decomposed during year applied

Dry matter	Poultry	Swine	Other	Compost
<18%	0.60	0.50	0.35	0.10
>18%	0.60	0.50	0.25	0.10

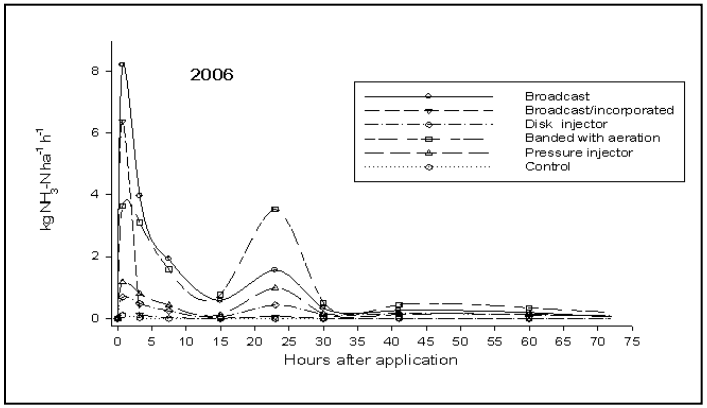
Organic N decomposed from past applications

Manure applied	Manure	Compost
1 yr ago	0.12	0.05
2 yrs ago	0.05	0.02
3 yrs ago	0.02	0.01
4 yrs ago	0.02	0.01
5 yrs ago	0.01	0.01

Adapted from Klausner and Bouldin, Cornell University; Jokela, University of Vermont; and Sims, University of Delaware.

Nitrogen Application Methods

- Incorporation
  - Incorporate ***urea*** containing sources (Urea, UAN, manure) as soon as possible to reduce volatilization losses
    - 30% loss from urea possible within 1 week
    - ~$50 worth of N
  - Tillage, ½ in. soaking rain
    - ***Timing is critical***
      - Most of the loss is in the first 48 hours
    - Coordinate fertilizer/manure application and tillage/rain

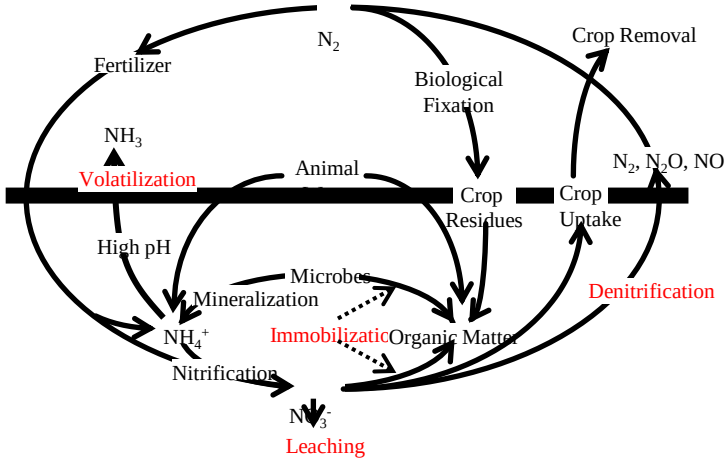


Nitrogen Application Methods

- Injection
  - Economics ???
  - Time required is a concern
  - Soil disturbance – no-till
  - Combined with planting works very well
    - 4-6 in. from the row
- Banding
  - Surface banding usually reduces volatilization significantly compared to broadcasting
    - Surface dribbling, almost as good as injection
- Urease Inhibitors
  - Substitute for incorporation of urea

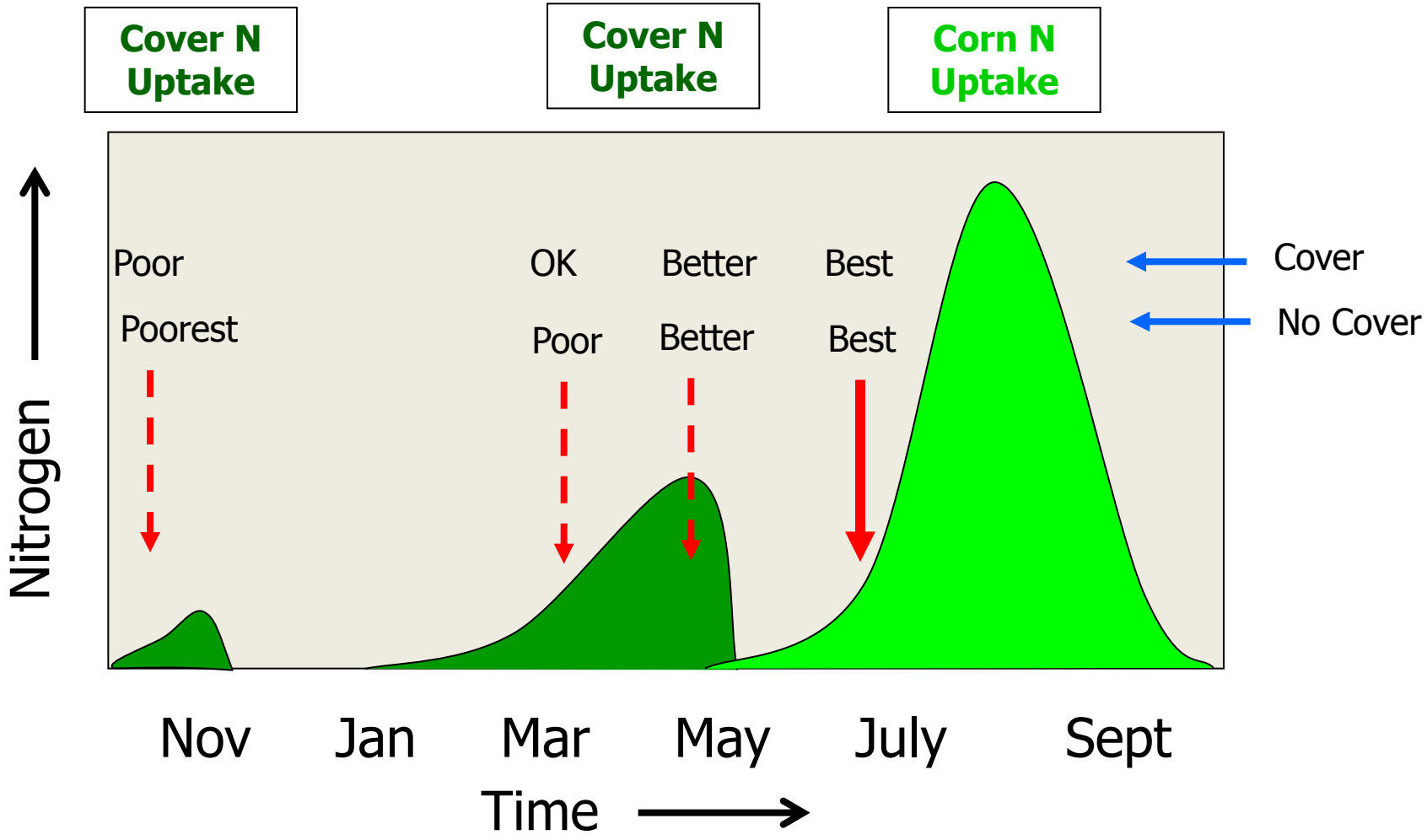
N Application Timing

- N Behavior is very dynamic
  - Once applied many things can happen to the N – most of them are negative
- Apply as near to time of crop need as possible
- Avoid periods of high potential loss
- Nitrification inhibitors
  - Substitute for better timing



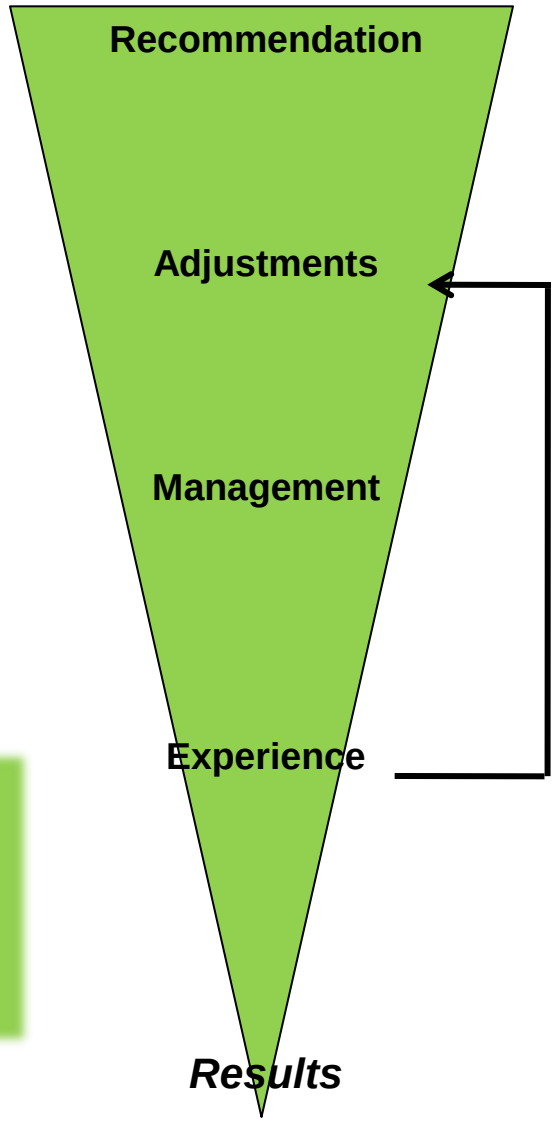
N Application Timing

As near to crop use as practical



N Management Process

- Recommendations
  - Crude, but hopefully educated guesses
  - Get us started in the ballpark
- Adjustments
  - Rough estimates
    - Legumes
    - Manure
  - Refine the guesses
    - PSNT or Chlorophyll Meter
- Management
  - Source, method and timing of application
- Experience
  - N Management is a series of successive approximations
    - Late Season Stalk Nitrate Test
    - Check strips
  - Records



Tools for Adjusting N Management

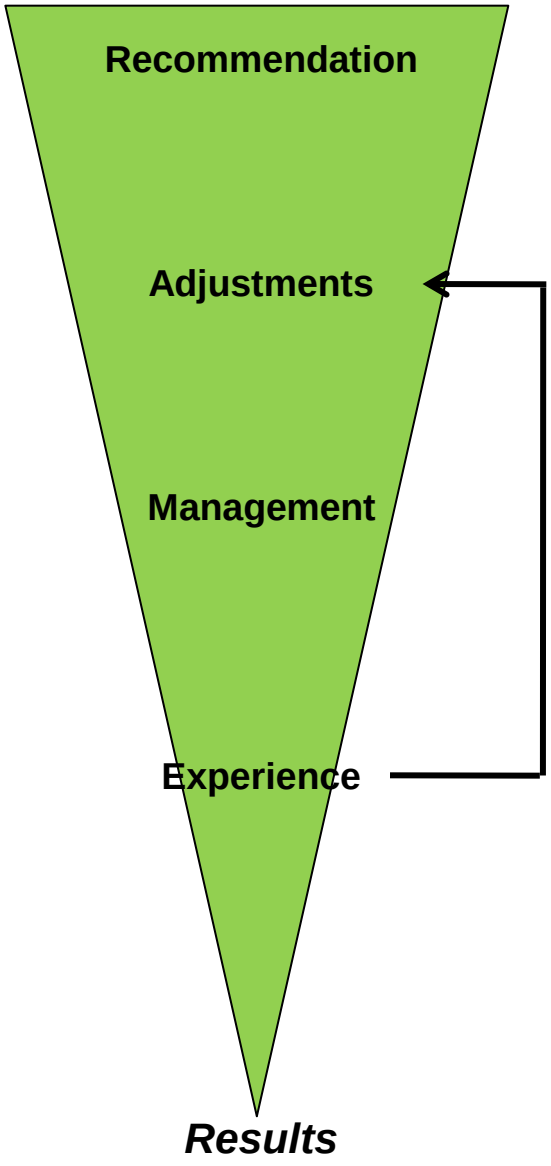
- Late Season Stalk Nitrate Test
  - Excellent postmortem assessment of N management
  - Procedure
    - Sample between ¼ milkline and 3 weeks after black layer
    - 8” piece of stalk 6” above the ground
    - Cut into little pieces, dry and send to the lab
    - Optimum 700-2000 ppm NO_3-N

Using Strip Tests to Improve Management

- Manure History Impact
  - Manure more than 8/last 10 years
  - Normal N = 112 lb N/A
    - Yield = 187 bu/A
    - LSSNT = 5783 ppm NO_3-N
  - Normal + N = 150 lb N/A
    - Yield = 192 bu/A
    - LSSNT = 6947 ppm NO_3-N
  - What does this tell us?
    - Manure more than 8 out of last 10 years
    - High LSSNT even at the low rate of N
    - Likely did not need this much N
    - Next year try a plot Normal –N?

N Management Process

- Recommendations
  - Crude, but hopefully educated guesses
  - Get us started in the ballpark
- Adjustments
  - Rough estimates
    - Legumes
    - Manure
  - Refine the guesses
    - PSNT & Chlorophyll Meter
    - In-season N tests double the accuracy of sidedress N recommendations
- Management
  - Source, method and timing of application
- Experience
  - N Management is a series of successive approximations
    - Late Season Stalk Nitrate Test
    - Check strips
  - Records



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