N Ledger Nitrogen Management Software

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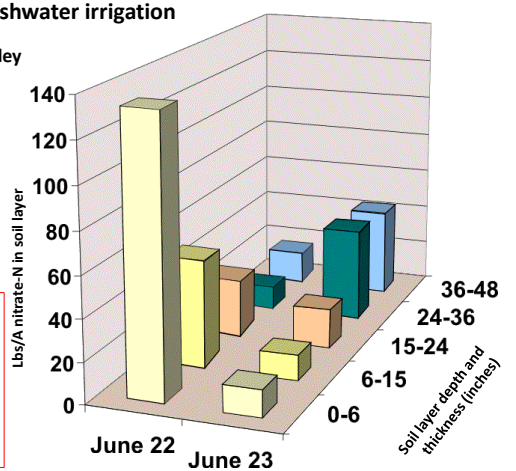
Two basic approaches to reducing N leaching:

1. Improve irrigation efficiency so water doesn't move past roots

Parcel size and shape prohibits sprinklers in Northern San Joaquin Valley
Drip with lagoon water may not be viable on a large scale

Nitrate-N losses (lbs/acre) from a single freshwater irrigation

N. San Joaquin Valley
silage corn
1st irrigation
6.7 ac-in
fine sandy loam



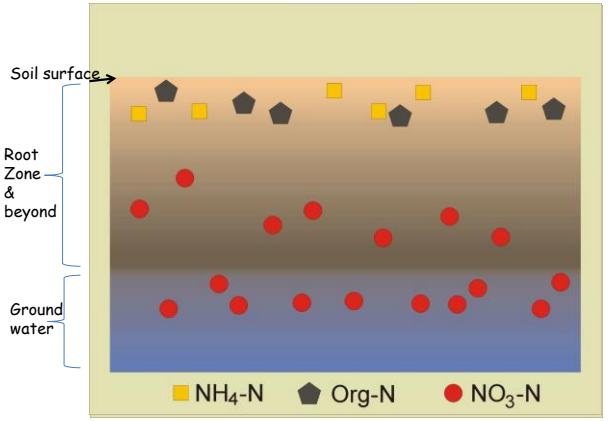
On 12 sites
(loam to sand or sandy loam soils),

averaged > 50 % loss of N in top 2 ft of soil
(Irrigations averaged 5-7 inches)

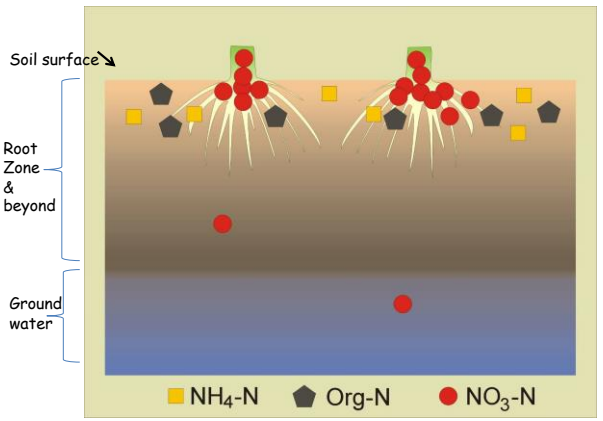
Two basic approaches to reducing N leaching:

1. Improve irrigation efficiency so water doesn't move past roots

2. **Strategic timing of applications so there is a minimal amount of nitrate in the soil during leaching events**



Slide source: Marsha Campbell Mathews University of California Agronomy Farm Advisor



Slide source: Marsha Campbell Mathews University of California Agronomy Farm Advisor

Strategic timing of applications can minimize the amount of nitrate in the soil profile when losses are expected.

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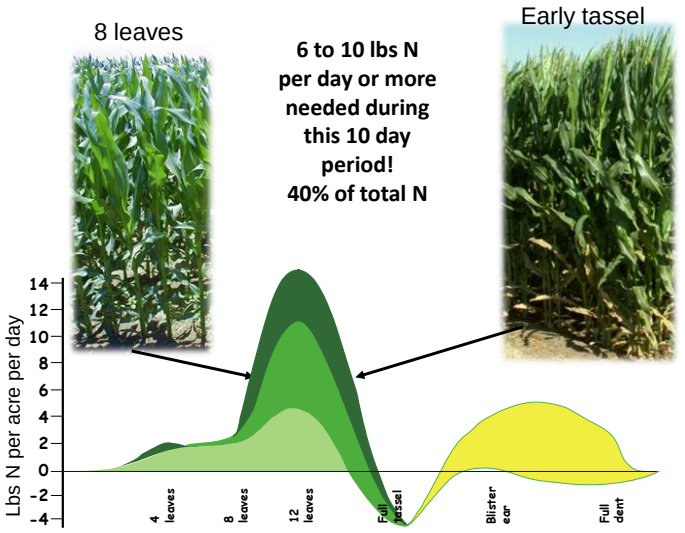

Organic form nitrogen

Releases slowly over years
Multiple forms
Multiple applications per year

Assets:

- Nitrate in irrigation water
- Mineralized N from organic sources this year & previous
- N fertilizer residual from previous crop

Losses:

- leaching with rainfall or irrigation
- denitrification

Goal:

- have N in soil when crop needs it
- don't have N in soil when it can be lost

Irrigation schedule

User entry

Days between

ET scheduling

Event	Event date	material mineralization type	ammon N lbs/A	organic N lbs/A	irrig nitrate N lbs/A	irrig ac-inches
	11 Sep 00					
w pre irrig	23 Oct 00				11.1	6.8
winter planting	*1 Dec 00*					
w 1st irrig	26 Feb 01	Lagoon Water	182	71	4.8	6.1
w 2nd irrig	28 Mar 01				16.5	10.2
w 3rd irrig	17 Apr 01				11.3	7.2
winter harvest	*11 May 01*					
s pre irrig	25 May 01				3.2	8.6
summer planting	*2 Jun 01*					
s 1st irrig	22 Jun 01				2.6	5.7
s 2nd irrig	3 Jul 01	Lagoon Water	25	14	4.9	7.0
s 3rd irrig	12 Jul 01	Lagoon Water	47	18	3.7	5.8
s 4th irrig	22 Jul 01	Lagoon Water	39	17	3.1	6.6
s 5th irrig	2 Aug 01	Lagoon Water	41	17	3.5	6.3
s 6th irrig	11 Aug 01				3.9	6.0
s 7th irrig	22 Aug 01	Lagoon Water	33	24	2.7	6.0
s 8th irrig	2 Sep 01				8	6.0
s 9th irrig	12 Sep 01				5.3	8.9
summer harvest	*21 Sep 01*					
fall planting	*23 Sep 01*					
fall harvest	*1 Dec 01*					
	totals	613	367	161	84.6	97.2

Irrigation amount

Nitrate in irrigation water

Event	Event date	material mineralization type	ammon N lbs/A	organic N lbs/A	irrig nitrate N lbs/A	irrig ac-inches
	11 Sep 00					
w pre irrig	23 Oct 00				11.1	6.8
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winter harvest	*11 May 01*					
s pre irrig	25 May 01				3.2	8.6
summer planting	*2 Jun 01*					
s 1st irrig	22 Jun 01				2.6	5.7
s 2nd irrig	3 Jul 01	Lagoon Water	25	14	4.9	7.0
s 3rd irrig	12 Jul 01	Lagoon Water	47	18	3.7	5.8
s 4th irrig	22 Jul 01	Lagoon Water	39	17	3.1	6.6
s 5th irrig	2 Aug 01	Lagoon Water	41	17	3.5	6.3
s 6th irrig	11 Aug 01				3.9	6.0
s 7th irrig	22 Aug 01	Lagoon Water	33	24	2.7	6.0
s 8th irrig	2 Sep 01				8	6.0
s 9th irrig	12 Sep 01				5.3	8.9
summer harvest	*21 Sep 01*					
fall planting	*23 Sep 01*					
fall harvest	*1 Dec 01*					
	totals		613	367	161	84.6	97.2

Material type applied

Event	Event date	material mineralization type	ammon N lbs/A	organic N lbs/A	irrig nitrate N lbs/A	irrig ac-inches
	11 Sep 00					
w pre irrig	23 Oct 00				11.1	6.8
winter planting	*1 Dec 00*					
w 1st irrig	26 Feb 01	Lagoon Water	182	71	4.8	6.1
w 2nd irrig	28 Mar 01				16.5	10.2
w 3rd irrig	17 Apr 01				11.3	7.2
winter harvest	*11 May 01*					
s pre irrig	25 May 01				3.2	8.6
summer planting	*2 Jun 01*					
s 1st irrig	22 Jun 01				2.6	5.7
s 2nd irrig	3 Jul 01	Lagoon Water	25	14	4.9	7.0
s 3rd irrig	12 Jul 01	Lagoon Water	47	18	3.7	5.8
s 4th irrig	22 Jul 01	Lagoon Water	39	17	3.1	6.6
s 5th irrig	2 Aug 01	Lagoon Water	41	17	3.5	6.3
s 6th irrig	11 Aug 01				3.9	6.0
s 7th irrig	22 Aug 01	Lagoon Water	33	24	2.7	6.0
s 8th irrig	2 Sep 01	commercial			8	6.0
s 9th irrig	12 Sep 01	Lagoon Water			5.3	8.9
summer harvest	*21 Sep 01*	Dairy Cow Manure				
fall planting	*23 Sep 01*					
fall harvest	*1 Dec 01*					
	totals		613	367	161	84.6	97.2

Ammonia form lbs/acre

Organic form lbs/acre

Event	Event date	material mineralization type	ammon N lbs/A	organic N lbs/A	irrig nitrate N lbs/A	irrig ac-inches
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w pre irrig	23 Oct 00				11.1	6.8
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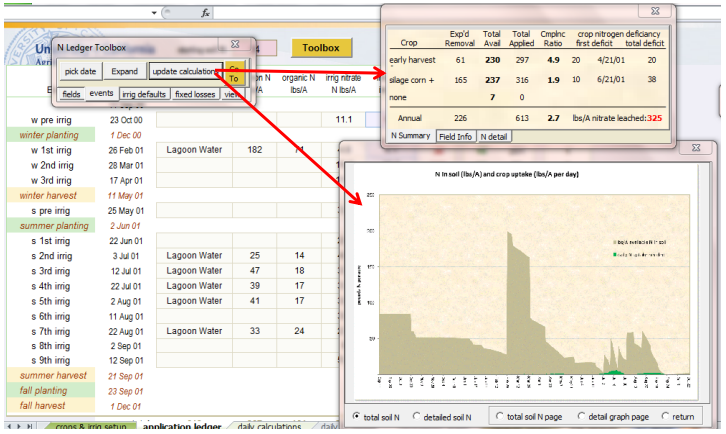
w 1st irrig	26 Feb 01	Lagoon Water	182	71	4.8	6.1
w 2nd irrig	28 Mar 01				16.5	10.2
w 3rd irrig	17 Apr 01				11.3	7.2
winter harvest	*11 May 01*					
s pre irrig	25 May 01				3.2	8.6
summer planting	*2 Jun 01*					
s 1st irrig	22 Jun 01				2.6	5.7
s 2nd irrig	3 Jul 01	Lagoon Water	25	14	4.9	7.0
s 3rd irrig	12 Jul 01	Lagoon Water	47	18	3.7	5.8
s 4th irrig	22 Jul 01	Lagoon Water	39	17	3.1	6.6
s 5th irrig	2 Aug 01	Lagoon Water	41	17	3.5	6.3
s 6th irrig	11 Aug 01				3.9	6.0
s 7th irrig	22 Aug 01	Lagoon Water	33	24	2.7	6.0
s 8th irrig	2 Sep 01				8	6.0
s 9th irrig	12 Sep 01				5.3	8.9
summer harvest	*21 Sep 01*					
fall planting	*23 Sep 01*					
fall harvest	*1 Dec 01*					
	totals		613	367	161	84.6	97.2

Event	Event date	irrig nitrate N lbs/A	irrig ac-inches	total NO_3 leached	crop N this period	avail N this period	mineralized N this period
	10/11/08						
w pplnt 1	12 Oct 08					36	1
w pre irrig	16 Oct 08	8	4.0	14		35	4
w pplnt 2	29 Oct 08			3	1	82	0
winter planting	*30 Oct 08*				87	95	13
w insn 1	4 Feb 09			6	37	55	2
w 1st irrig	1 Mar 09	6	3.0	3	55	70	4
winter harvest	*4 Apr 09*					15	1
s pre irrig	9 Apr 09	8	4.0	6	0	18	1
s insn 1	20 Apr 09				21	35	7
s 1st irrig	1 Jun 09	6	3.0	2	45	60	2
s 2nd irrig	15 Jun 09	6	3.2	3	88	99	2
s 3rd irrig	26 Jun 09	6	3.1	2	24	67	2
s 4th irrig	7 Jul 09	6	3.2	6	5	45	2
s 5th irrig	19 Jul 09	6	3.0	5	27	93	1
s 6th irrig	29 Jul 09	4	2.0	2	60	71	3
summer harvest	*18 Aug 09*					11	0
fall planting	*20 Aug 09*					18	7
fall harvest	*30 Oct 09*						
	totals	56	28.5	51	450		53

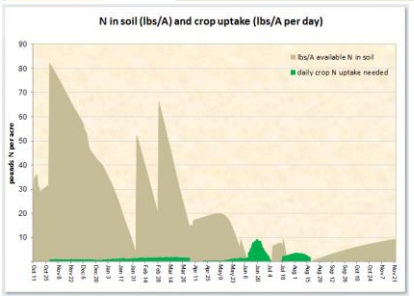


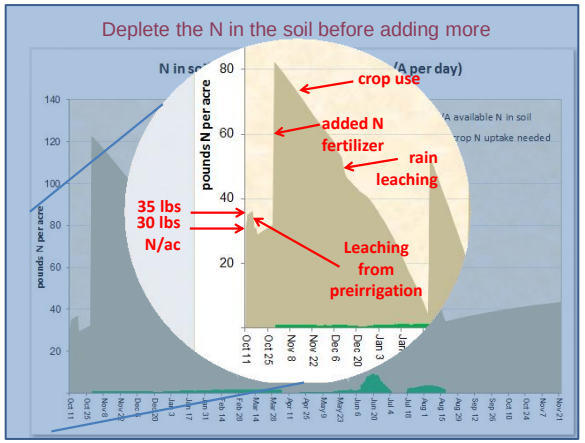
Crop	Exp'd Removal	Total Avail	Total Applied	Cmplnc Ratio	crop nitrogen deficiancy first deficit	total deficit
early harvest forage	61	**230**	297	**4.9**	20	4/21/01	20
silage corn + roots	165	**237**	316	**1.9**	10	6/21/01	38
none		**7**	0				
Annual	226		613	**2.7**	lbs/A nitrate leached:**325**		

N Summary | Field Info | N detail

Winter silage: 3 fertilizer applics: **50** at planting, **50** Feb. topdress, **45** at spring irrigation

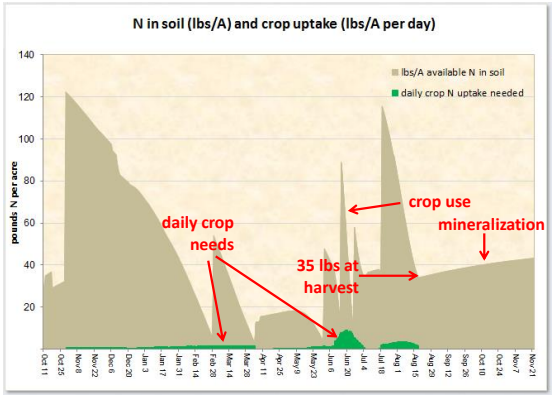
Event	Event date	material mineralization type	ammon N lbs/A	organic N lbs/A	irrig nitrate N lbs/A	irrig ac-inches	total NO_3 leached	crop N this period	avail N this period	mineralized N this period
	10/11/08									
w pplnt 1	12 Oct 08	Dairy Cow Manure	5	270					36	1
w pre irrig	16 Oct 08				8	4.0	14		35	4
w pplnt 2	29 Oct 08	commercial	50				3	1	82	0
winter planting	*30 Oct 08*							87	95	13
w insn 1	4 Feb 09	commercial	50				6	37	55	2
w 1st irrig	1 Mar 09	commercial	45		6	3.0	3	55	70	4
winter harvest	*4 Apr 09*								15	1





Brown shading is lbs available N/acre in soil & the green is **daily** corn N uptake

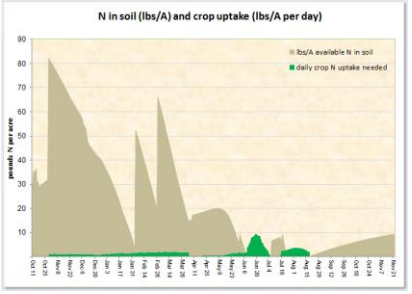
Deplete the N in the soil before adding more



Brown shading is lbs available N/acre in soil & the green is **daily** corn N uptake

Winter silage: **3** fertilizer applics: **50** at planting, **50** Feb. topdress, **45** at spring irrigation

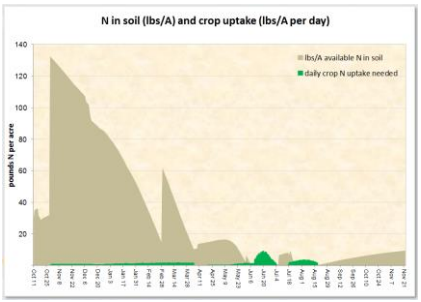
Event	Event date	material mineralization type	ammon N lbs/A	organic N lbs/A	irrig nitrate N lbs/A	irrig ac-inches	total NO_3 leached	crop N this period	avail N this period	mineralized N this period
	10/11/08									
w pplnt 1	12 Oct 08	Dairy Cow Manure	5	270					36	1
w pre irrig	16 Oct 08				8	4.0	14		35	4
w pplnt 2	29 Oct 08	commercial	50				3	1	82	0
winter planting	*30 Oct 08*							87	95	13
w insn 1	4 Feb 09	commercial	50				6	37	55	2
w 1st irrig	1 Mar 09	commercial	45		6	3.0	3	55	70	4
winter harvest	*4 Apr 09*								15	1



32 lbs N leached

Winter silage: **2** fertilizer applics: **100** at planting, **45** with spring irrigation

Event	Event date	material mineralization type	ammon N lbs/A	organic N lbs/A	irrig nitrate N lbs/A	irrig ac-inches	total NO_3 leached	crop N this period	avail N this period	mineralized N this period
	10/11/08									
w pplnt 1	12 Oct 08	Dairy Cow Manure	5	270					36	1
w pre irrig	16 Oct 08				8	4.0	14		35	4
w pplnt 2	29 Oct 08	commercial	100				3	1	132	0
winter planting	*30 Oct 08*							124	147	16
w 1st irrig	1 Mar 09	commercial	45		6	3.0	13	55	65	4
winter harvest	*4 Apr 09*								11	1



36 lbs N leached

N Ledger used for

- Developing N budgets
- In-season management decisions

N Records program tracks applications and sends results to the N Ledger for immediate visualization of current and projected soil N status

- Commercial fertilizer
- Manure application amounts
- Irrigation water amounts
- Nitrate in water
- Expected (and actual) N removal at harvest

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Accommodates difficult situations:

- leaching that cannot be controlled through irrigation management
- variable and/or unpredictable N application rates such as lagoon water
- manure or other organic form N based systems

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Who will use this program?

Best: person who makes N management decisions

Many growers will need help with set up and customization

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Use in conjunction with soil testing and leaf color monitoring

Soil N can be re-set to match soil test results

Uses published equations that can be customized

Excel platform expandable template that can accommodate new information and additional functions

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Manure.ucdavis.edu

SAREP solution center

mcmathews@ucanr.edu

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UCCE Nitrogen Ledger Calculator

Event	Event date	material mineralization type	ammon N lbs/A	organic N lbs/A	irrig nitrate N lbs/A	irrig ac-inches
date 1	3 May 14					
s pplnt 1	4 May 14	Dairy Cow Manure		180		
s pre irrig	6 May 14				18	8.0
summer planting	*16 May 14*					
s 1st irrig	12 Jun 14				11	5.0
s 2nd irrig	22 Jun 14				7	3.0
s 3rd irrig	2 Jul 14				7	3.0
s 4th irrig	12 Jul 14				7	3.0
s 5th irrig	22 Jul 14				7	3.0
s 6th irrig	1 Aug 14				7	3.0
s 7th irrig	11 Aug 14				7	3.0
s 8th irrig	21 Aug 14				7	3.0
summer harvest	*29 Aug 14*					
	totals	258	0	180	78	34.0

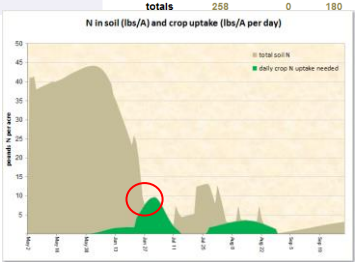
10 mg/L x .226 x 8 ac-in

N removal = 250

UCCE Nitrogen Ledger Calculator

Event	Event date	nitrate N lbs/A	irrig ac-inches	total NO_3 leached	crop N this period	avail N this period	mineralized N this period	soil test soil N
date 1	3 May 14					41	0	41
s pplnt 1	4 May 14					42	1	
s pre irrig	6 May 14	18	8.0	22	0	41	3	
summer planting	*16 May 14*			0	10	47	7	
s 1st irrig	12 Jun 14	11	5.0	13	18	38	2	
s 2nd irrig	22 Jun 14	7	3.0	3	76	26	2	
s 3rd irrig	2 Jul 14	7	3.0		53	2	2	
s 4th irrig	12 Jul 14	7	3.0		2	7	2	
s 5th irrig	22 Jul 14	7	3.0		11	14	2	
s 6th irrig	1 Aug 14	7	3.0		30	12	2	
s 7th irrig	11 Aug 14	7	3.0		34	5	1	
s 8th irrig	21 Aug 14	7	3.0		17	5	1	
summer harvest	*29 Aug 14*							
	totals	78	34.0	38	250		23	

Event	Event date	material mineralization type	ammon N lbs/A	organic N lbs/A	nitrate N lbs/A	irrig ac-inches	total NO_3 leached	crop N this period	avail N this period	soil test soil N	mineralized N this period
date 1	3 May 14								41	41	0
s pplnt 1	4 May 14	Dairy Cow Manure		180					42		1
s pre irrig	6 May 14				18	8.0	22	0	41		3
summer planting	*16 May 14*						0	10	47		7
s 1st irrig	12 Jun 14				11	5.0	13	18	38		2
s 2nd irrig	22 Jun 14				7	3.0	3	76	26		2
s 3rd irrig	2 Jul 14				7	3.0		53	2		2
s 4th irrig	12 Jul 14				7	3.0		2	7		2
s 5th irrig	22 Jul 14				7	3.0		11	14		2
s 6th irrig	1 Aug 14				7	3.0		30	12		2
s 7th irrig	11 Aug 14				7	3.0		34	5		1
s 8th irrig	21 Aug 14				7	3.0		17	5		1
summer harvest	*29 Aug 14*										
	totals		258	0	180	78	34.0	38	250		23

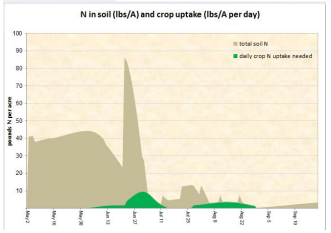


Crop	Exp'd Removal	Total Avail	Total Applied	Cmplnc Ratio	crop nitrogen deficiency first deficit	total deficit
none		1	0			
Silage Corn	250	101	258	1.0	101 6/27/14	160
none		4	0			
Annual	250		258	1.0	lbs/A nitrate leached: 38	

N Summary | Field Info | N detail

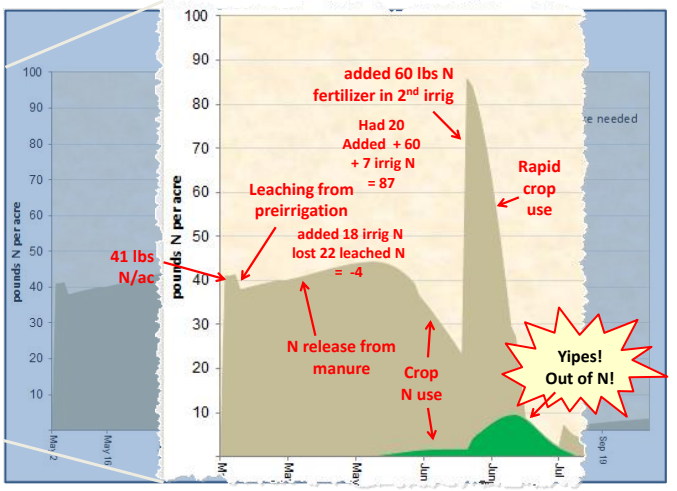
Brown shading is lbs available N/acre in soil & the green is **daily** corn N uptake

Event	Event date	material mineralization type	ammon N lbs/A	organic N lbs/A	nitrate N lbs/A	irrig ac-inches	total NO_3 leached	crop N this period	avail N this period	mineralized N this period
date 1	3 May 14								41	0
s pplnt 1	4 May 14	Dairy Cow Manure		180					42	1
s pre irrig	6 May 14				18	8.0	22	0	41	3
summer planting	*16 May 14*						0	10	47	7
s 1st irrig	12 Jun 14				11	5.0	13	18	38	2
s 2nd irrig	22 Jun 14	commercial	60		7	3.0	3	76	86	2
s 3rd irrig	2 Jul 14				7	3.0		53	79	2
s 4th irrig	12 Jul 14				7	3.0		2	35	2
s 5th irrig	22 Jul 14				7	3.0		11	41	2
s 6th irrig	1 Aug 14				7	3.0		30	39	2
s 7th irrig	11 Aug 14				7	3.0		34	48	1
s 8th irrig	21 Aug 14				7	3.0		17	22	1
summer harvest	*29 Aug 14*								5	
	totals		318	60	180	78	34.0	38	250	23



Crop	Exp'd Removal	Total Avail	Total Applied	Cmplnc Ratio	crop nitrogen deficiency first deficit	total deficit
none		1	0			
Silage Corn	250	161	318	1.3	34 7/4/14	93
none		4	0			
Annual	250		318	1.3	lbs/A nitrate leached: 38	

N Summary | Field Info | N detail



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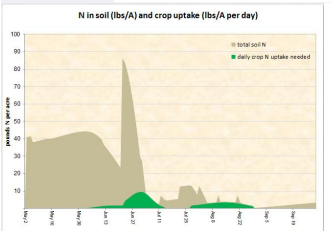
summer planting	*16 May 14*						0	10	47	7
s 1st irrig	12 Jun 14				11	5.0	13	18	38	2
s 2nd irrig	22 Jun 14	commercial	60		7	3.0	3	76	86	2
s 3rd irrig	2 Jul 14				7	3.0		53	79	2
s 4th irrig	12 Jul 14				7	3.0		2	35	2
s 5th irrig	22 Jul 14				7	3.0		11	41	2
s 6th irrig	1 Aug 14				7	3.0		30	39	2
s 7th irrig	11 Aug 14				7	3.0		34	48	1
s 8th irrig	21 Aug 14				7	3.0		17	22	1
summer harvest	*29 Aug 14*								5	
	totals	318	60	180	78	34.0	38	250		23



Crop	Exp'd Removal	Total Avail	Total Applied	Cmplnc Ratio	crop nitrogen deficiency first deficit	crop nitrogen deficiency total deficit
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Silage Corn	250	161	318	1.3	34 7/4/14	93
none		4	0			
Annual	250		318	1.3	lbs/A nitrate leached: 38	

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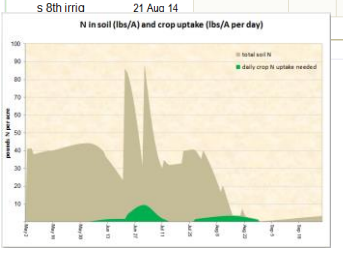
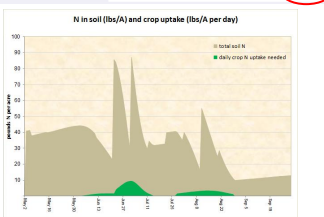
date 1	3 May 14								41	0
s pplnt 1	4 May 14	Dairy Cow Manure		180					42	1
s pre irrig	6 May 14				18	8.0	22	0	41	3
summer planting	*16 May 14*						0	10	47	7
s 1st irrig	12 Jun 14				11	5.0	13	18	38	2
s 2nd irrig	22 Jun 14	commercial	60		7	3.0	3	76	86	2
s 3rd irrig	2 Jul 14	commercial	60		7	3.0		53	79	2
s 4th irrig	12 Jul 14				7	3.0		2	35	2
s 5th irrig	22 Jul 14				7	3.0		11	41	2
s 6th irrig	1 Aug 14				7	3.0		30	39	2
s 7th irrig	11 Aug 14				7	3.0		34	18	1
s 8th irrig	21 Aug 14				7	3.0		17	5	1
				180	78	34.0	38	250		23



Crop	Exp'd Removal	Total Avail	Total Applied	Cmplnc Ratio	crop nitrogen deficiency first deficit	crop nitrogen deficiency total deficit
none		1	0			
Silage Corn	250	221	378	1.5	16 8/16/14	28
none		4	0			
Annual	250		378	1.5	lbs/A nitrate leached: 38	

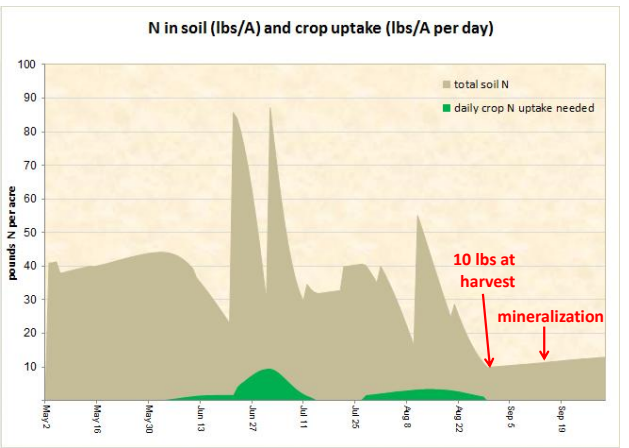
N Summary | Field Info | N detail

Event	Event date	material mineralization type	ammon N lbs/A	organic N lbs/A	nitrate N lbs/A	irrig ac-inches	total NO_3 leached	crop N this period	avail N this period	mineralized N this period
date 1	3 May 14								41	0
s pplnt 1	4 May 14	Dairy Cow Manure		180					42	1
s pre irrig	6 May 14				18	8.0	22	0	41	3
summer planting	*16 May 14*						0	10	47	7
s 1st irrig	12 Jun 14				11	5.0	13	18	38	2
s 2nd irrig	22 Jun 14	commercial	60		7	3.0	3	76	86	2
s 3rd irrig	2 Jul 14	commercial	60		7	3.0		53	79	2
s 4th irrig	12 Jul 14				7	3.0		2	35	2
s 5th irrig	22 Jul 14				7	3.0		11	41	2
s 6th irrig	1 Aug 14				7	3.0		30	39	2
s 7th irrig	11 Aug 14	commercial	35		7	3.0		34	53	1
s 8th irrig	21 Aug 14				7	3.0		17	27	1
summer harvest	*29 Aug 14*								10	
	totals	413	155	180	78	34.0	38	250		23



Crop	Exp'd Removal	Total Avail	Total Applied	Cmplnc Ratio	crop nitrogen deficiency first deficit	crop nitrogen deficiency total deficit
none		1	0			
Silage Corn	250	256	413	1.7	no N deficit	
none		4	0			
Annual	250		413	1.7	lbs/A nitrate leached: 38	

N Summary | Field Info | N detail



Brown shading is lbs available N/acre in soil & the green is **daily** corn N uptake

Event	Event date	material mineralization type	ammon N lbs/A	organic N lbs/A	nitrate N lbs/A	irrig ac-inches	total NO_3 leached	crop N this period	avail N this period	mineralized N this period
date 1	3 May 14								41	0
s pplnt 1	4 May 14	Dairy Cow Manure		180					42	1
s pre irrig	6 May 14				18	8.0	22	0	41	3
summer planting	*16 May 14*						0	10	47	7
s 1st irrig	12 Jun 14				11	5.0	13	11	37	2
s insn 1	18 Jun 14	commercial	170					7	197	1
s 2nd irrig	22 Jun 14				7	3.0	19	76	180	2
s 3rd irrig	2 Jul 14				7	3.0		53	113	2
s 4th irrig	12 Jul 14				7	3.0		2	68	2
s 5th irrig	22 Jul 14				7	3.0		11	75	2
s 6th irrig	1 Aug 14				7	3.0		30	73	2
s 7th irrig	11 Aug 14				7	3.0		34	51	1
s 8th irrig	21 Aug 14				7	3.0		17	25	1
summer harvest	*29 Aug 14*								8	
	totals	428	170	180	78	34.0	54	250		23

54 lbs N leached vs
38 with split applications

If shanked in before 1st irrigation, needed to apply 220 lbs and leached 110 lbs

Event	Event date	material mineralization type	ammon N lbs/A	organic N lbs/A	nitrate N lbs/A	irrig ac-inches	total NO_3 leached	crop N this period	avail N this period	mineralized N this period
date 1	3 May 14								41	0
s pplnt 1	4 May 14	Dairy Cow Manure		180					42	1
s pre irrig	6 May 14				18	8.0	22	0	41	3
summer planting	*16 May 14*						0	10	47	7
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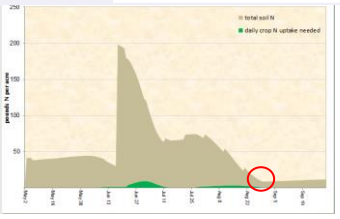
s insn 1	18 Jun 14	commercial	170					7	197	1
s 2nd irrig	22 Jun 14				7	3.0	19	76	180	2
s 3rd irrig	2 Jul 14				7	3.0		53	113	2
s 4th irrig	12 Jul 14				7	3.0		2	68	2
s 5th irrig	22 Jul 14				7	3.0		11	75	2
s 6th irrig	1 Aug 14				7	3.0		30	73	2
s 7th irrig	11 Aug 14				7	3.0		34	51	1
s 8th irrig	21 Aug 14				7	3.0		17	25	1
summer harvest	*29 Aug 14*								8	
	totals	428	170	180	78	34.0	54	250		23



78 lbs N from irrigation nitrate
23 lbs N from mineralization

8 lbs N at harvest

Soil and tissue testing confirmation

Traditional N recommendations based on typical fertilizer rates

Groundwater protection emphasizes N budgets

potential yield (N removal)
previous crop residue and soil organic N
irrigation water nitrate
compensate for losses

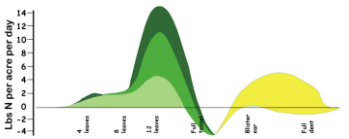
potential for nitrate leaching

timing applications with crop uptake
- **crop uptake curves**
- **mineralization of organic N sources**
- **leaching events, magnitude and frequency**

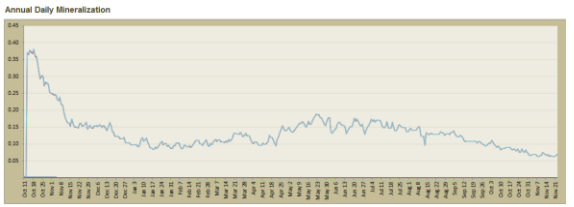
Need to consider and rough calculate:

Crop uptake needs throughout season
How much irrigation water N to credit
Organic N mineralization
Estimate leaching losses

We have been calculating these by hand



Have a prototype calculator that does all of them simultaneously



Traditional N recommendations based on typical fertilizer rates

Groundwater protection emphasizes N budgets

- **potential yield (N removal)**
- **previous crop residue and soil organic N**
- **irrigation water nitrate**
- **compensate for losses**

potential for nitrate leaching