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Nitrate loss reduction in rainy winters by autumn application of high C:N ratio amendments



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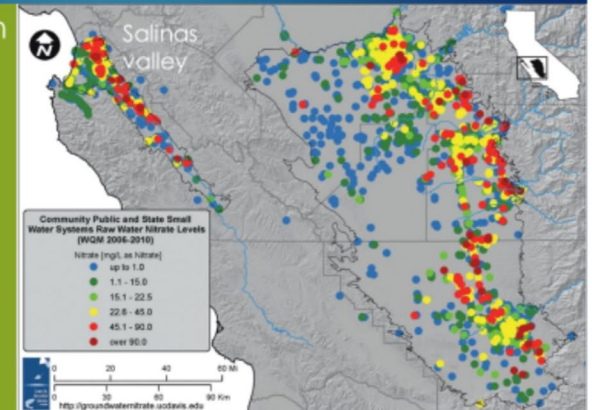
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Nitrate contaminated groundwater

- ~254,000 people in Tulare Lake Basin and Salinas Valley face health risks

- Main causes:

1. Agricultural fertilizers and animal wastes applied to croplands
2. Autumn incorporation of N-rich crop residues



Maximum reported raw-level nitrate concentration in community public water systems and state-documented state small water systems, 2006-2010. Source: CDPH PICME WQM Database.

(Center for Watershed Science, 2012)

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Background

- ▶ Broccoli and cauliflower; ~220 lb-biomass N/acre in residues grown at 150,000 acres in CA (2013)
- ▶ Winter soil temp at 6" depth; 50-59°F
- ▶ ~120 lb/ac of broccoli-derived N lost in a broccoli field after 5" of rain in Dec (Smith et al., 2016)
- ▶ Cover crop not used for winters



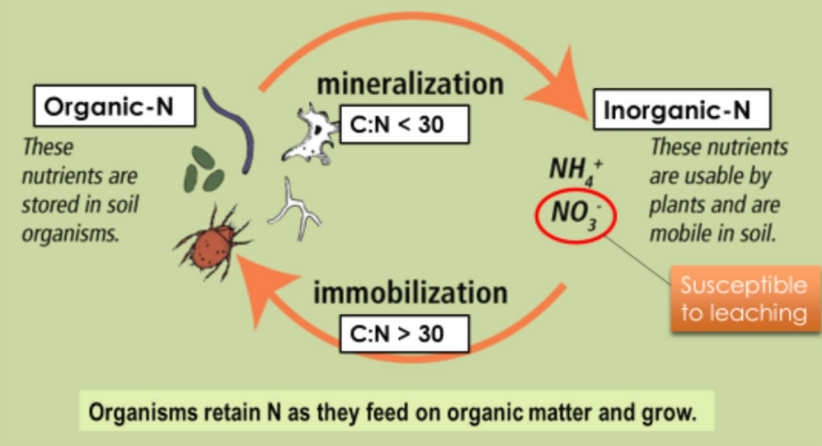
- ▶ Studies in EU and Canada; use of high CN amendment to immobilize residual N in soil (Chaves et al., 2007 and many others)
- ▶ Compost application in Autumn; a common practice in Salinas valley
- ▶ Switching compost to high CN amendment ... a Best Management Practice?



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N immobilization vs. N mineralization

Organisms consume organic matter and excrete inorganic N.



(Adopted from USDA-NRCS, 2017)

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Outline

- ▶ **Part 1: Survey of high C:N ratio amendments**
 - C:N, chemical composition, price, availability in CA
- ▶ **Part 2: Incubation studies**
 - ▶ Broccoli residues + selected amendments
 - ▶ 68/59 °F, 60% WFPS, RCB, 4 reps
 - ▶ Monitor soil inorganic N biweekly for 12 to 16 weeks
- ▶ **Part 3: Field trials**
 - ▶ Broccoli-lettuce or broccoli-strawberry
- ▶ **Part 4: Economic analysis**

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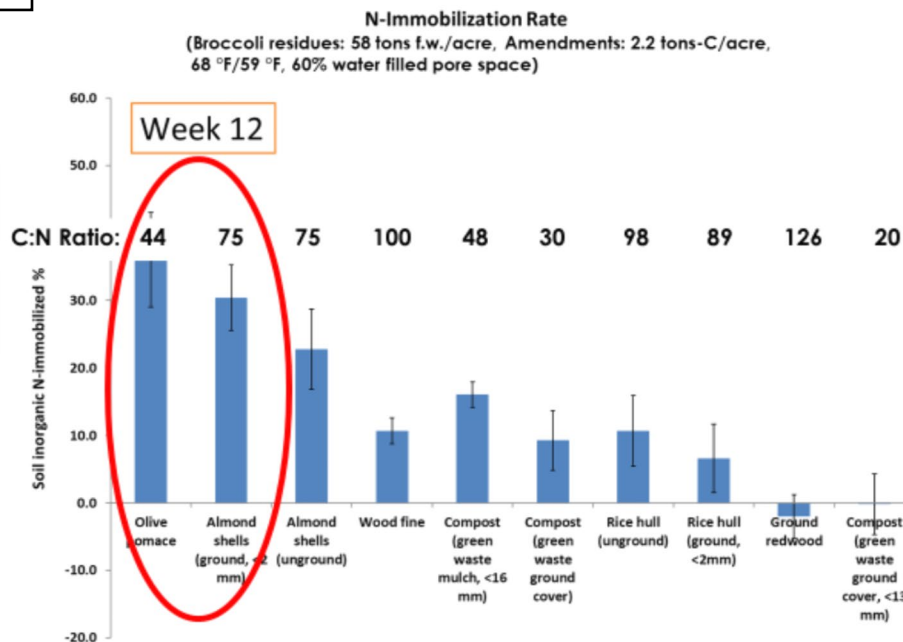
Potential organic amendments for N immobilization in California

Organic amendment	C:N	Price (\$/ton)	Availability in CA (ton, annual)
Green waste mulch	48	35	3,700,000*
Green waste ground cover	30	35	3,700,000*
Almond shell (ground)	44	70	1,000,000
Ground redwood	126	50	>10,000
Olive pomace	44	100	50,000
Rice hull	80	25	80,000
Wood fine	100	50	>20,000
Crude glycerol	>1,555	330	50,000

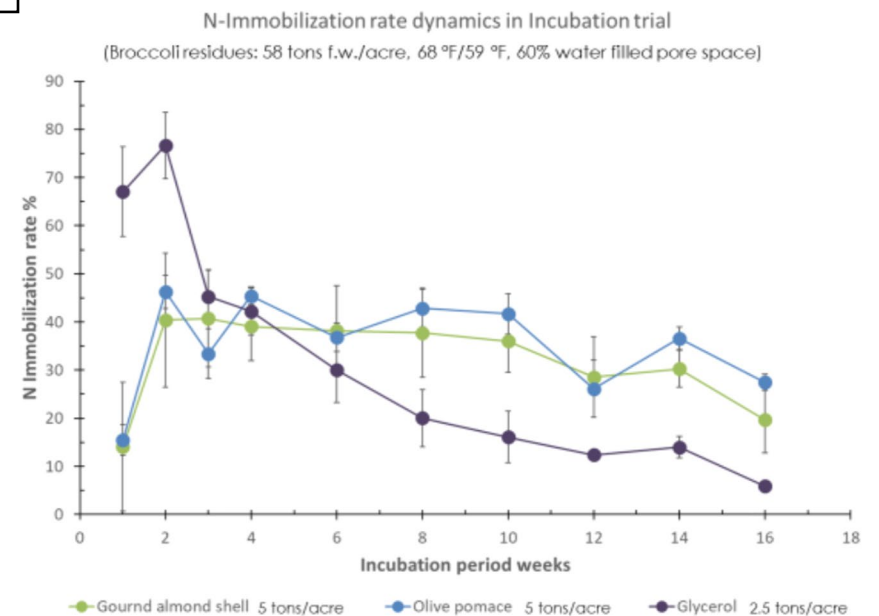
* All types of green waste composts combined

(Keith Day, Farm Fuel, and others, 2016-2018)

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Field Trials (Randomized complete block design)

► Broccoli – Lettuce rotation (Conv. Silty clayloam. 4 reps)

- 2017-18; Ground almond shell (GAS) 5 tons/acre
GAS 10 tons/acre
Glycerol 2.5 tons/acre
GAS 5 tons/acre + Glycerol 1.25 tons/acre
Untreated control (UTC)

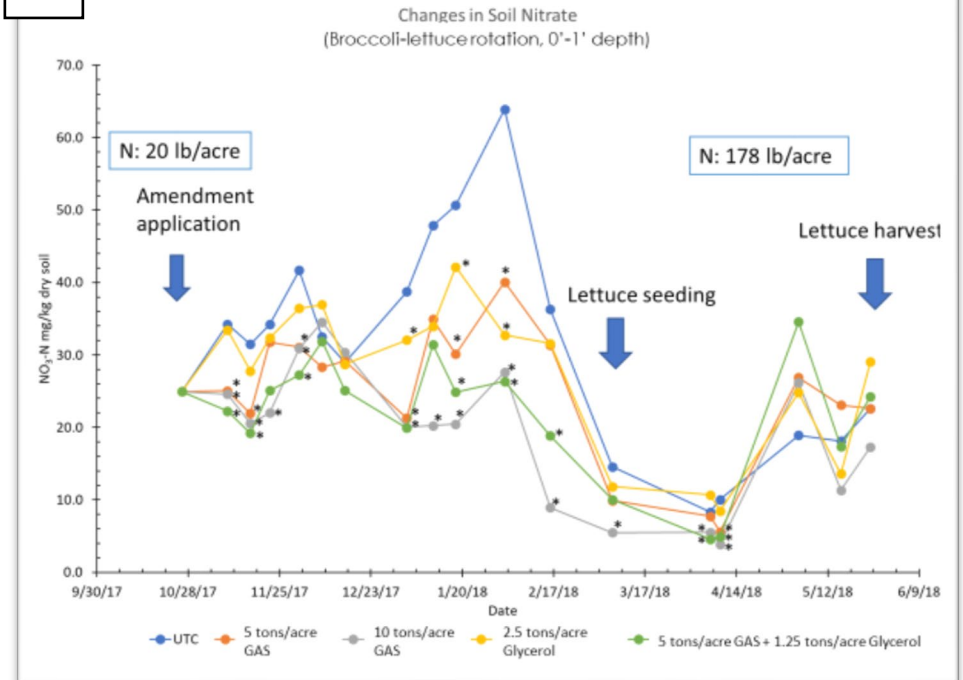


► Broccoli – Strawberry rotation (Organic. Clay. 3 reps)

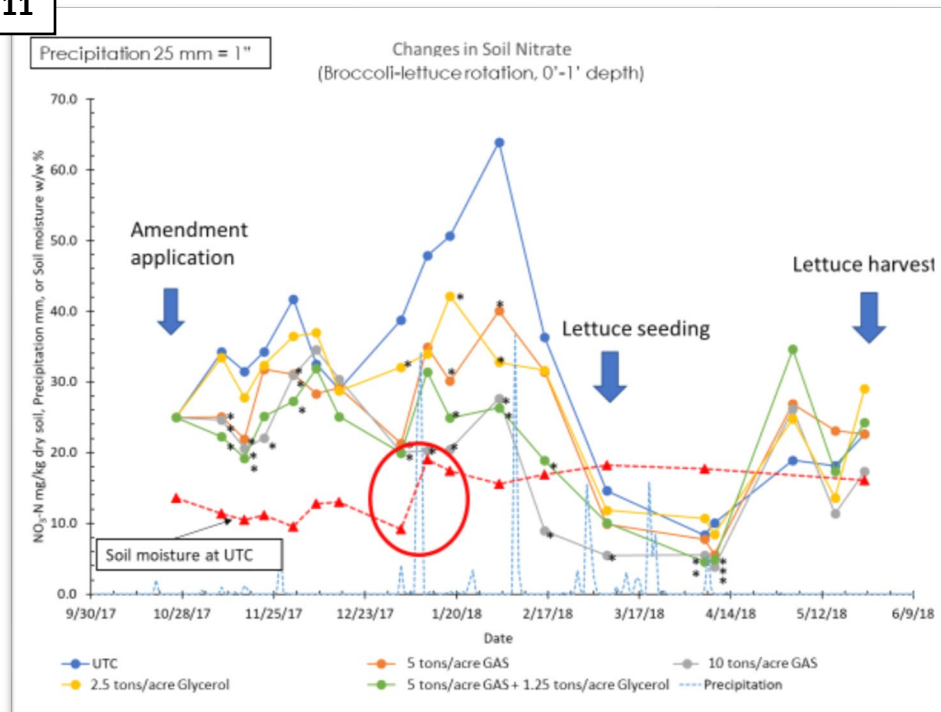
- 2017-18; GAS 5 tons/acre
Ground olive pomace (GOP) 5 tons/acre
UTC

- Each plot: 100' x 20'
- Soil inorganic N monthly at 0'-1', 1'-2', 2'-3' depth
- Yield of successive crop

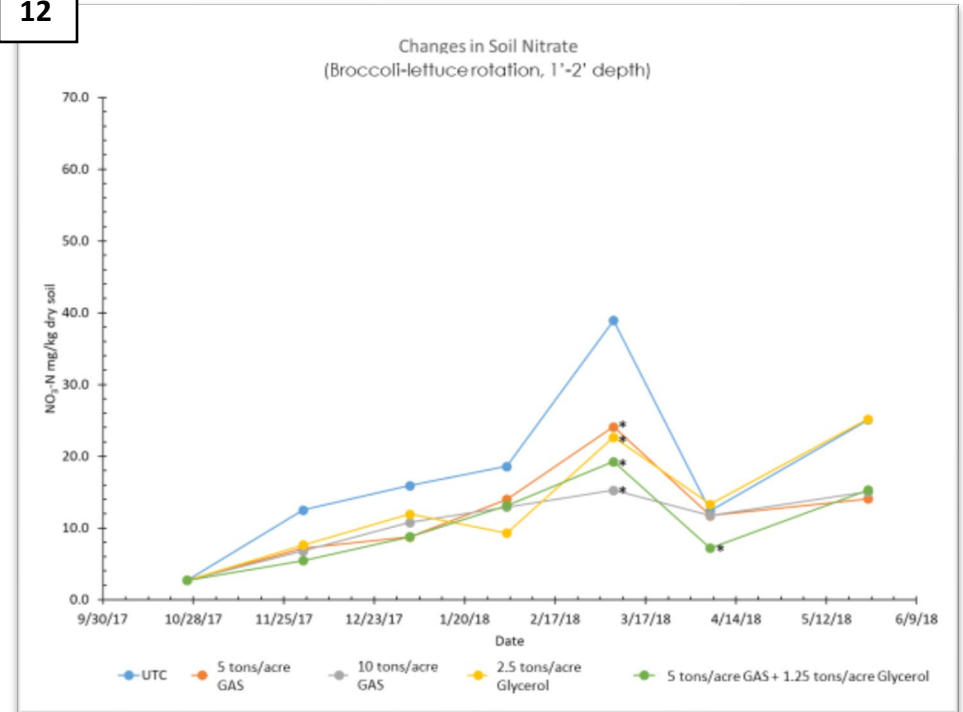
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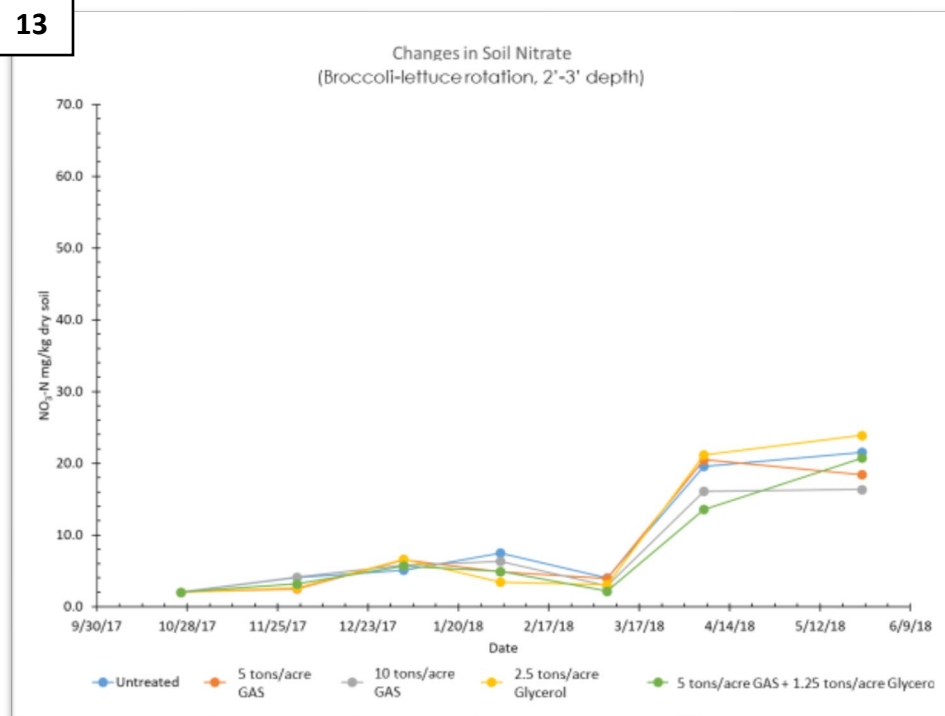


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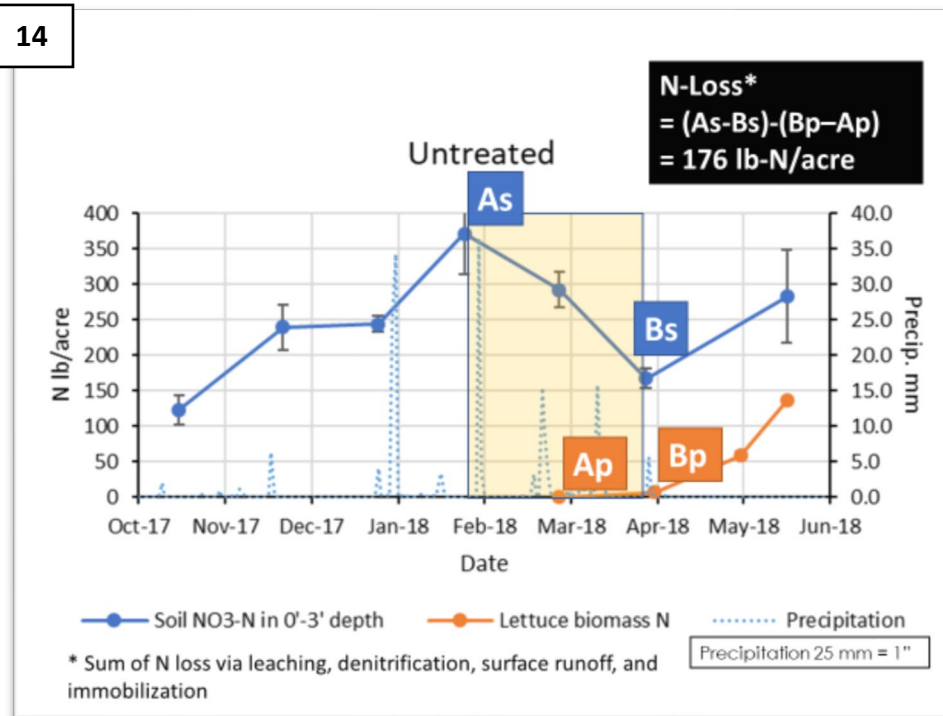


N-immobilization. Annual Santa Maria Strawberry Field Day. 5/14/2019. Muramoto 4

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Estimated Nitrate Loss and Its Reduction (Feb. – Apr. 2018)

Treatment	Soil Nitrate on Feb. 2	Soil Nitrate on Apr. 6	Plant N uptake*	Est. Nitrate loss	Nitrate loss Reduction
	lb-N/acre/0'-3' depth		lb-N/acre		%
UTC	332	150	6.5	176	-
GAS 5	219	150	6.0	63	64
GAS 10	176	125	6.3	45	75
Glyc. 2.5	173	169	6.0	-2.8	102
GAS 5+ Glyc. 1.25	163	94.5	7.7	61	65

* Based on measured biomass-N data and Bottoms et al., 2012.

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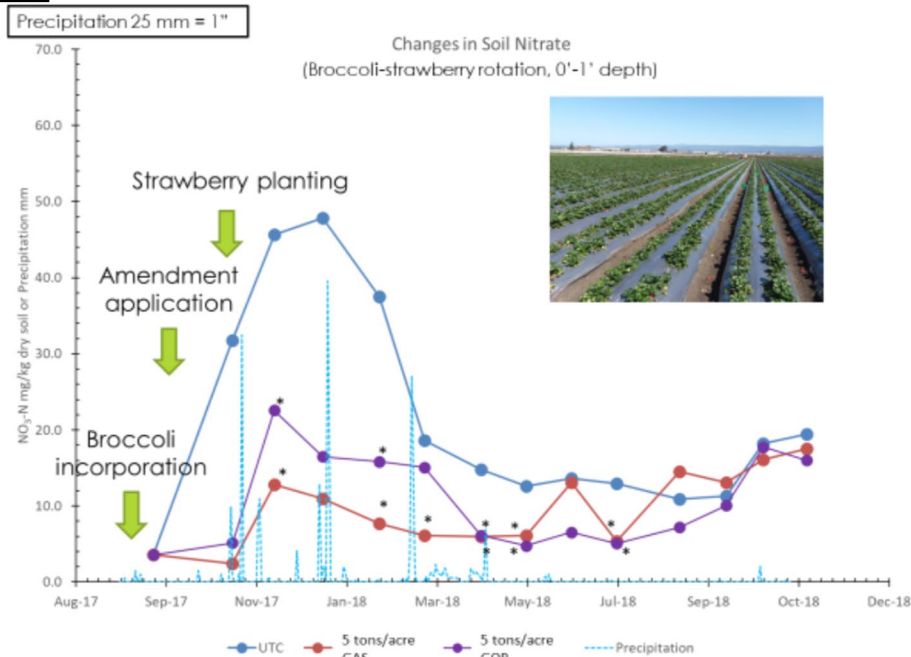
Iceberg Lettuce Yield and Economics

Treatment	Marketable yield (tons/acre)	Amendment cost (\$/acre)	Net return above pre-plant and harvest costs (\$/acre)
UTC	23.4a*	130**	5,468
GAS 5	22.8a	400	5,047
GAS 10	14.6b	800	2,468
Glyc. 2.5	24.2a	850	4,956
GAS 5 + Glyc. 1.25	21.3a	825	4,213

* Averages with the same letter have no significant difference according to Tukey's HSD test at P=0.001.

** UTC assumed compost 2 tons/acre.

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Strawberry Yield and Economics

Treatment	Marketable yield (tons/acre)	Amendment cost (\$/acre)	Net return above pre-plant and harvest costs (\$/acre)
UTC	32.6b*	325**	11,924
GAS 5	41.0a	400	13,077
GOP 5	34.5ab	550	12,553

*Averages with the same letter have no significant difference according to Tukey's HSD test at P=0.05.

** UTC assumed compost 5 tons/acre.

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Summary & Future Plan

- Autumn application of ground almond shell, ground olive pomace, and glycerol appear to be promising in reducing nitrate loss in rainy winters in coastal CA
- Rate of immobilization and re-mineralization varied among amendments → C:N and labile C?
- **Lettuce**: no effect on yield except for ground almond shell 10 tons/acre, but **none of them are economically feasible**
- **Strawberry**: ground almond shell 5 tons/acre increased yield and the net return above pre-plant and harvest costs
- Will **repeat both rotation trials** focusing on less expensive amendments and/or reduced rates

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