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# Nitrogen Management in Organic Strawberries: Challenges and Approaches

Joji Muramoto and Carol Shennan, University of California Santa Cruz Mark Gaskell, UC Cooperative Extension

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Joji Muramoto UCSC Carol Shennan UCSC Mark Gaskell UC Cooperative Extension Nitrogen Management in Organic Strawberries: challenges and approaches



Joji Muramoto<sup>1</sup>, Carol Shennan<sup>1</sup> and Mark Gaskell<sup>2</sup>

<sup>1</sup> University of California, Santa Cruz <sup>2</sup>University of California Cooperative Extension San Luis Obispo and Santa Barbara Cos., CA. (USA)

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### Overview

- 1. Organic Strawberry Production in California (CA)
- 2. Nitrogen (N) Management in Organic Strawberries
  - a. Synchronizing N Supply with Plant N Demand
  - b. Challenges for N Management in Organic Strawberries in CA
  - c. N Uptake by Organic Strawberries
  - d. N Supply for Organic Strawberries
- 3. Fertigation Efficiency Trial
- 4. Pre-plant/In-season N Field Trials in the Northern District
- 5. Summary
- 6. Future Studies

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Santa Cruz, CA (1980-2010 Normal) Mediterranean climate with mild and dry summer allows the 30 year -long strawberry 250 production in CA 200 Moderate summer Precip. mm temperatures permit 150 harvest over extended 100 season -20 224253328028 Month University of California Agriculture and Natural Resource SANTA CRUZ













### Nitrogen: A key to crop production

- · Primary nutrient limiting plant growth
- Inorganic (nitrate NO<sub>3</sub><sup>-</sup> or ammonium NH<sub>4</sub><sup>+</sup>) or organic form in soil
- Organic N has to be mineralized to inorganic forms to be absorbed by most crops
- Rapid turnover in soil microbial activity nitrate is soluble in water - moves readily in soil solution but susceptible to leaching

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Synchronizing Nitrogen Supply with Nitrogen Demand

 Matching N supply with N demand of strawberry plants

 amount and timing

Important for:

- Efficient use of N resource
  Protect ground and surface water from nitrate
- Reduce N fertilizer cost
- Critical for strawberry yield



Asynchrony of N supply and N demand (Robertson, 1997) Challenges for N management in organic strawberries in CA

Extended harvest season

Dec.- June (So. dist.), Feb.- Aug (Central), March-Nov. (No. dist.)

- day neutral varieties may be cutback for year around harvest

- · Variable soil organic matter and unpredictable SOM mineralization
- Release from pre-plant incorporated organic material does not coincide with plant demand
- Leaching of N with winter rains.

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Challenges for N management in organic strawberries in CA (continued)
Low soil organic matter (SOM) sandy soil in some areas

- · Limited options for manipulation of SOM
- Limited rotation / green manure alternatives in typical strawberry cropping system
- · Problems with efficient in-season fertigation

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### N Supply: Organic N sources

- Traditionally, organic growers concentrate on soil organic matter (SOM) management as basis for organic production program
- N mineralization residue, cover crop or compost lasts 8-10 weeks
   does not match the N needs of the strawberry crop
- Cycling of N in soil organic fraction, microbial activity
   dynamic depends on environmental conditions

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Material	Total N %	C/N ratio	1 week	4 weeks	8 weeks	24 weeks
Blood meal	15.8	3.1	51	67	70	-
Feather meal	14.2	3.5	50	64	63	-
Fish powder	13.7	3.4	48	60	64	-
Sea bird guano	11.1	1.3	45	48	54	-
Pelletized poultry manure	2.8	8.6	10	23	36	-
Manure (poultry, feedlot)	2.7	11	-	-	-	15
Manure compost (poultry, feedlot, dairy)	1.9	9.8	-	-	-	6
Plant residue compost	1.6	14.2	-	-	-	2
Incubated at 77 °F. (Hartz and Johnstone 2004; Hartz et al., 2000)						















N Supply: Need of In-season N applications

- In-season band application and cultivation with organic pelleted or milled fertilizer...impractical under plasticulture CA strawberry systems
- Fertigation: liquid organic fertilizer applications via drip tapes are popular among organic strawberry growers in CA....but some issues

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Anecdotal data for poor fertigation performance
"Small plants" and lower yields relative to conventional fields

- Rapid plugging of system filters
- · Little or no effects on soil N or yield from varying rate field trials
- · Early deterioration of distribution uniformity
- · Low tissue N test regardless of fertigation in organic strawberries

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# Pre-plant/In-season N Trials in the Northern District

- Goal: To examine effects of types and rates of pre-plant and in-season N applications to fruit yield and N dynamics in organic strawberry production
- Approach: Four seasons of randomized block split-plot on-farm trials with <u>In-season N</u> as main plots and <u>pre-plant N</u> as split plots in Watsonville, CA (4 reps)
- Monitored fruit yield, soil inorganic N (0"-12" depth), plant biomass N
- cv. Seascape

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### Season Site Main plots (In-season N\*) Split plots (Pre-plant N) 2005-06 Site-1\*\* 50, 100, 150 lb-N/ac Sudan grass (SG) Site-1\*\* with liquid organic fertilizer SG + Feather meal 50 lb-N/ac (SG+FM)

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		SG + Compost 5 t/ac (SG+CP)		
2006-07 Site-2**	75, 150, 225 lb-N/ac with liquid organic fertilizer	None (0) Sudan grass (SG) Compost 10 t/ac (CP)		
+ Diment	ha ann llan daon dhacan da Adam da	0-1		

Biweekly applications through Mar. to Oct.
 Managed by a small scale diversified grower
 Grower's standard practice.





















Sudan grass					
Season Site	Biomass d.w. t/ac	N %	Biomass Ib-N/ac	C/N	
2005-06 (Site-1)	3.6	2.3	166	17	
2006-07 (Site-2)	4.7	1.4	132	31	
	2005 (Site-1	)		2006 (Site-2)	

Season Site	Main plots (In-season N*)	Split plots (Pre-plant N)
2007-08 Site-3** 2008-09 Site-4**	0, 150, 300 lb-N/ac with liquid organic fertilizer	Compost 5 t/ac (CP) CP + Blood meal 75 lb-N/ac (CP+BM75) CP + Blood meal150lb-N/ac (CP+BM150)
* Biweek	aly applications through Mar. to ad by a large scale specialized	Oct. grower











N loss and Winter Weather (Nov. 1 - Jan. 31. Watsonville, CA)

Season Site	Mean N loss Ib-N/ac	Precip. inch	Mean Max. Air Temp ⁰F	Mean Min. Air Temp. ºF
2005-06 (Site-1)	110	15.2 (+3.5)*	64.2 (+1.4)	42.8 (+2.3)
2006-07 (Site-2)	-24	6.6 (-5.1)	62.8 (±0)	38.8 (-1.6)
2007-08 (Site-3)	17	10.7 (-0.9)	61.5 (-1.1)	39.6 (-0.9)
2008-09 (Site-4)	29	6.1 (-5.6)	64.9 (+2.2)	41.0 (+0.5)

\* Difference from the 30 yr mean (1979-2008).

# Discussion

### Pre-plant Compost (seasons 1-2)

- No significant effect in yield and soil/plant N dynamics in a short term Sudan grass cover crop (seasons 1-2)
- Low C/N (17): quick N release and large N loss (as broccoli residues)
- High C/N (31): no early N release but no effect on yield in a short term Blood meal (seasons 3-4)
- Effective only in a dry-warm winter year (as it works in the Southern district)

In-season N

- No responses in 3 out of 4 seasons
- Partially due to low distribution efficiency?
- 300 lb-N/ac: increased marketable yield in one season (low overall yield) but increased cull rate in another season (high overall yield)

### Limiting winter N losses in the Northern region

Based on analysis of 6 field trials with 53 treatment combinations, we have found that N loss is strongly dependent upon:

- Residual soil nitrate from previous crop
- Amount of N added in crop residue immediately before strawberries
- Amount of pre-plant organic fertilizer (e.g. pelleted organic fertilizer, blood meal) added

<u>Rule of thumb</u>: to keep N losses below 50 lb-N/ac, don't add any pre-plant organic fertilizer if

- 1. Residual NO<sub>3</sub>-N is above ~25 mg/kg in 0'-1' soil depth
- 2. Broccoli residues\* were incorporated before planting strawberries \* normally provides 150 lb-N/ac

### SUMMARY - N Management in Organic Strawberries

- N demand by strawberries varies depending on the region and the fruit yield
  - In the Southern (warmer) region, N uptake increases faster than the Northern (colder) regions
    - Pre-plant N
      - more effective in the south than the north
      - · can increase fruit yield in dry-warm winters in the north
  - Total N uptake by strawberries can vary from 90 to 175 lb-N/ac depending on the yield

### SUMMARY - N Management in Organic Strawberries (Continued)

- Mineralized N from a crop residue, organic fertilizers and SOM does not match the long and steady N needs of strawberries
  - In-season N applications necessary
  - · Mineralized N from crop residues and residual soil nitrate
    - Major sources of excess N in fall and vulnerable to loss during rainy winter in the north
    - A guideline to limit N loss
- Fertigation of liquid organic fertilizer
  - common practice as the in-season N application but has some efficiency issues to be addressed
  - low yield of organic strawberries may partially be due to the low N supply during the harvest season?

### FUTURE STUDIES - N Management in Organic Strawberries

- Improving fertigation efficiency in organic strawberries
  - Effect of filter mesh size, high pressure agitation in a mixing chamber prior to injection, organic wetting agent/dispersant
- Reducing N loss during rainy winter
  - N loss estimation tool based on regression analysis
  - Immobilizing residual soil inorganic N by high C/N amendments
- Interaction between plant (root) health and N demand
  - Low yield of organic strawberries due to pathogen infection, N deficiency, or both?
  - N management under anaerobic soil disinfestation

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# Questions? Joji Muramoto joji@ucsc.edu Mark Gaskell: mlgaskell@ucanr.edu Carol Shennan cshennan@ucsc.edu Carol Shennan cshennan@ucsc.edu

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