Changes in the Central Coast organic leafy greens industry and it's influence on fertility management

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True Organic Products

Background in Leafy Greens Industry

- Worked for Mission Organics (2000 – 2013), a company that produced organic leafy greens for Earthbound Farm.
- Complete Ph.D. from UC Davis in 2002 (studying the biological control of mites/insect pests in agricultural systems).
- Worked for Internal Farming at Earthbound Farm (2013 – 2018), Director of agricultural research, pest management, fertility management, and baby-crop seed management.
- Over the last 18 years, I have been involved in the management of over 100,000 acres of organic leafy greens.
- On organic fertility issues, during my time working with Mission Organics and Earthbound Farm, I worked closely with the farming management team (Otto Kramm, Bodie Taylor, Robbie Long, Danny Solomon, and Larry Santos), our organic agronomist Gina Colfer and our head PCAs/CCAs (John DeCarli & Lee Carter). Together, we monitored crop fertility/performance, soil fertility/chemistry and performed many organic fertility trials.
- Currently working at True Organic Products, performing research agronomy in the R&D department with a team of scientists including a soil scientist (Ehsan Toosi), a chemists (Charles Grove), and myself.

Organic Farming Sector in California Agriculture is Substantial and Growing

- Organic sales in the U.S. totaled a new record of $49.4 billion in 2017, up 6.4 percent from the previous year and reflecting new sales of nearly $3.5 billion (OTA).
- Organic farms in the United States produced and sold $7.6 billion worth of organic products in 2016, a 23 percent increase from 2015 organic sales.
- California produced 38 percent of total U.S. farm commodity value for organics, with $2.9 billion in organic crops, poultry, livestock, and dairy products sold in 2017 (CCOF).

California County	Value of Organic Crops (2017)	Acres of Organic Farm Land (2017)
Monterey County	$390,295,000	40,859
Santa Cruz County	$109,058,000	6,702
San Benito County	$56,511,500	46,802
Ventura County	$197,386,000	8,851
Imperial County	?	45,216

Major Events for Organic Fertility Management on the Central Coast

1. **The establishment of dry pelleted organic fertilizer use.**
2. The advancement of cover crop use.
3. 2006 spinach E. coli outbreak and the formation of the Leafy Greens Marketing Agreement Metrics.
4. 2011 cases of fraud by two companies selling liquid organic fertilizers.
5. In 2020, Central Coast Regional Water Quality Control Board and the potential rules associated with Ag Order 4.0.

The Early Years – The challenges of large-scale organic leafy vegetable farming

- There were many people in the leafy greens industry that initially thought that the challenges were too great to grow organic leafy vegetables on a large-scale, year around.
- Even in UCCE, I recall a farm advisor telling me that the only reason grower companies were able to maintain organic programs was because their conventional programs were helping to subsidize their organic programs. This was not the case for Mission Organics.
- Mission Organics was 100% organic. Through observations, experimentation and good teamwork, we figured out how to consistently deliver leafy vegetable crops on a year around basis in an economically viable way.

Large-scale organic leafy vegetable farming

- Approaches:
  - Weed Management: Consistent, year-around weed control to drive down weed-seed bank. Used of high density cover crops (especially mustards). Solarization where appropriate.
  - Pest Management: Utilization of specific organic materials, rates, and timing with a focus on promoting and preserving biological control. Used flowering insectary strips to promote syrphid flies and predatory insects.
  - Disease Management: Utilization of host plant resistant varieties, crop rotation, cover crops, and some use of organic materials.

The Early Years – The challenges of large-scale organic leafy vegetable farming

Organic Fertility Management

- During the early 2000s, primary sources for nutrients we used was from
  - Annual Applications of Manure-based compost
  - Semi-annual cover crops
  - Applications of liquid organic fertilizer (applied as preplant and during cropping cycle).
  - Not much pelleted organic fertilizer was available.

- These programs were good but we sometimes encountered nitrogen deficiencies and low yields in our organic leafy green crops.

Large-scale organic leafy vegetable farming – Fertility Program Improvements

Approaches, Fertility Management:

1. Utilization of organic dry pelleted fertilizer with right rates, application technique and timing to consistently deliver optimal crop quality and yields.
2. Utilization of liquid fertilizers when supplementary nutrients were require in crops where dry programs were inadequate. Especially used near end of cropping cycle via fertigation.
3. Fall/Winter cover crops to improve soil fertility. Cover Crops were intensively used on transitional ground to improve soil fertility, reduce weed seed populations, reduce soil-borne diseases and improve soil quality for regular organic production.
4. Fall applications of compost to improve soil health and quality. However, this practice was discontinued sometime after 2006 due to fear of introducing food-borne pathogen.
5. Applications of other organically-compliant soil amendments to improve soil quality (gypsum, sulfur).

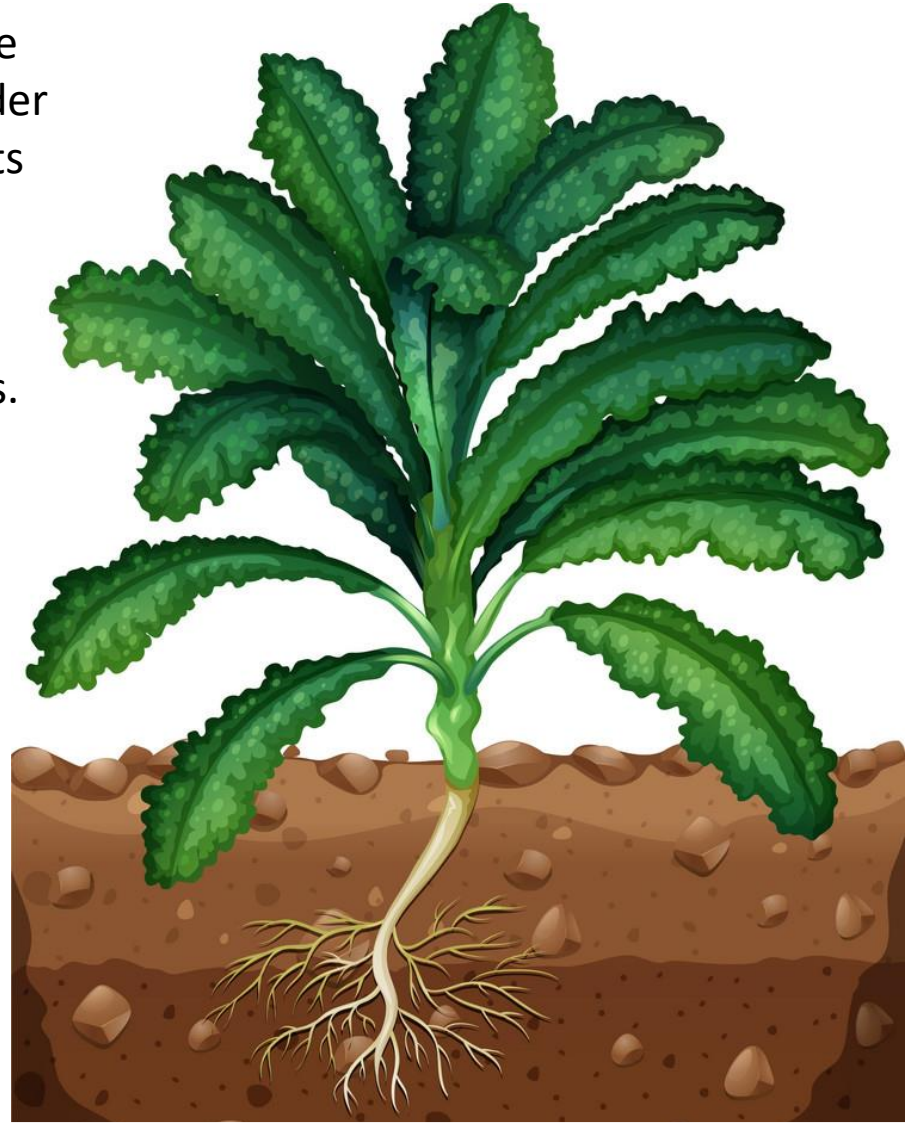
Pelleted dry organic fertilizer – very effective fertilizer for organic leafy greens

- Efficient and economical means to deliver NPK to baby crops and row crops. Crop nutrient responses are consistent throughout the year. Generally able to deliver nutrients when crop demand is greatest.
- Pelleted fertilizers makes it easier to deliver specific rates of material in a range of environmental conditions with less dust than powders.
- Pellet formulations can be customized to specific crops and soil conditions.
- On baby crops, best to apply a preplant application and incorporate pellets into soil (increases the mineralization rate of nitrogen).
- On row crops, best to apply preplant, then follow with multiple side-dress applications. Incorporate into soil when possible (without damaging crop).

Organic Pelleted Fertilizer

Organic fertilizer and amendments require decomposition by microbial activity in order to make nitrogen and most other nutrients available for crop uptake.

Organic fertilizer is food for soil microbes which, in turn, provides nutrients to crops.



Nitrogen in crude protein and other biomolecules are decomposed by microbial activity

Percentage of Nitrogen is mineralized through microbial decomposition and converted to Ammonium (NH4) & Nitrate (NO3) which is available for crop uptake

Carbon and other nutrients in biomolecules enter soil where they are decomposed via microbial activity, making Phosphorus and Potassium and other nutrients available to crops

Nitrogen not mineralized may remain in soil indefinitely as soil organic matter

True Organic Products Has a Wide Range of Dry Pelleted Organic Fertilizers (>100 products). Examples of some popular products.

Product	Ingredients
2.5 – 2 – 2.5	Poultry Manure
4 – 4 – 2	Poultry Manure, Meat & Bone Meal
6 – 6 – 2	Poultry Manure, Seabird Guano, Meat & Bone Meal
7.5 – 5 – 7.5	Meat & Bone Meal, Sulfate of Potash
8 – 5 – 1	Meat & Bone Meal, Poultry Manure, Feather Meal
10 – 2 – 8	Feather Meal, Meat & Bone Meal, Sulfate of Potash
10 – 5 – 2	Meat & Bone Meal, Feather Meal, Sulfate of Potash
10 – 10 – 2.5	Meat & Bone Meal, Seabird Guano, Sulfate of Potash
12 – 0 – 0	Feather Meal, Meat & Bone Meal
12 – 3 – 0	Feather Meal, Meat & Bone Meal
13 – 0 – 0	Feather Meal, Meat & Bone Meal

From R. Smith, UCCE
Monterey Co. Farm Advisor

Laboratory Incubations of Fertilizer Materials
Percent N Mineralized – High N fertilizers provide more nitrate to plants than low N fertilizers.

Material	2 weeks	4 weeks	8 weeks
2.5-2.0-2.5	4.0	5.8	13.6
4-4-2	28.8	30.5	37.5
8-5-1	47.2	43.5	58.5
10-5-2	43.8	49.3	58.8
12-0-0	48.7	56.5	59.3

Lab evaluations generally had lower levels of N mineralization than field measurements.

From R. Smith, UCCE
Monterey Co. Farm Advisor

In-field Fertilizer Mineralization Studies

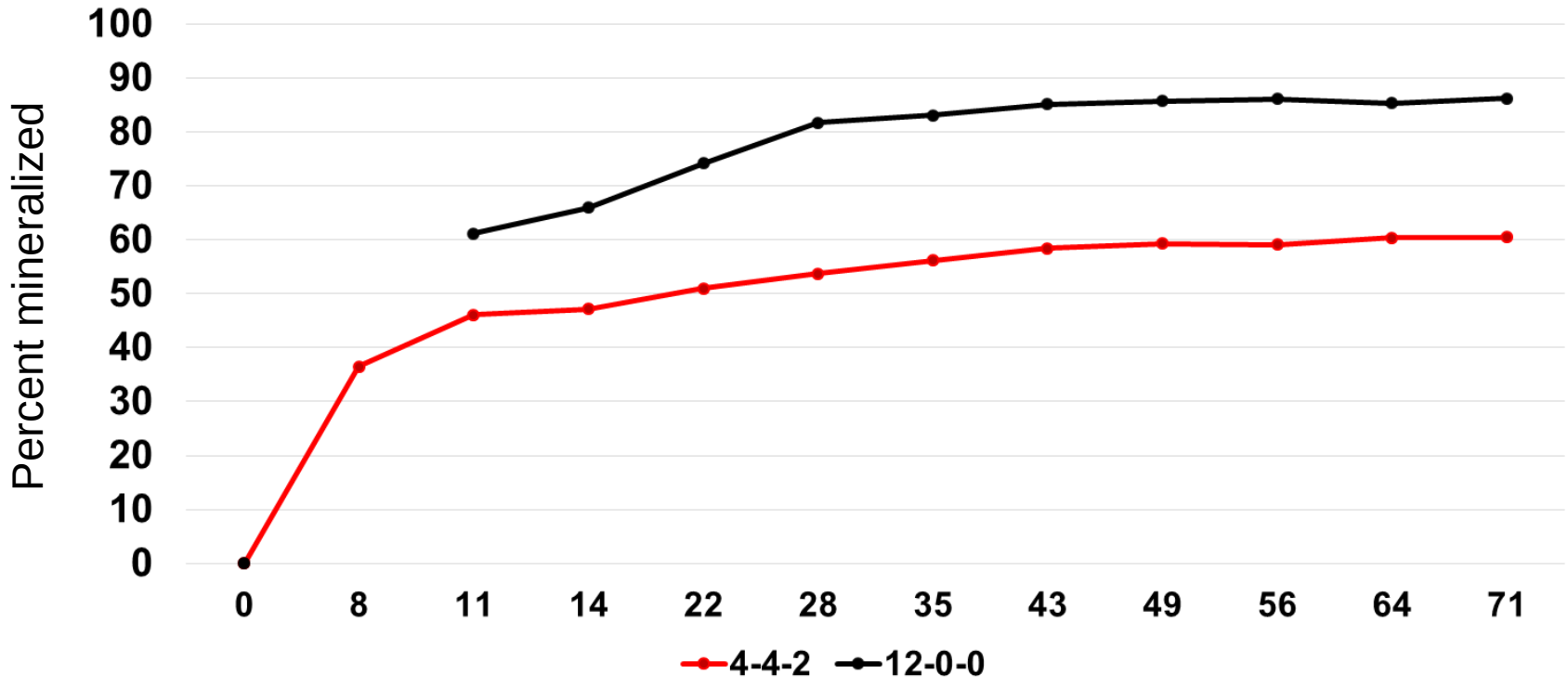
Buried in soil

Place on top of soil

4 pouches collected weekly and analyzed for N, P & K over the crop cycle

From R. Smith, UCCE
Monterey Co. Farm Advisor

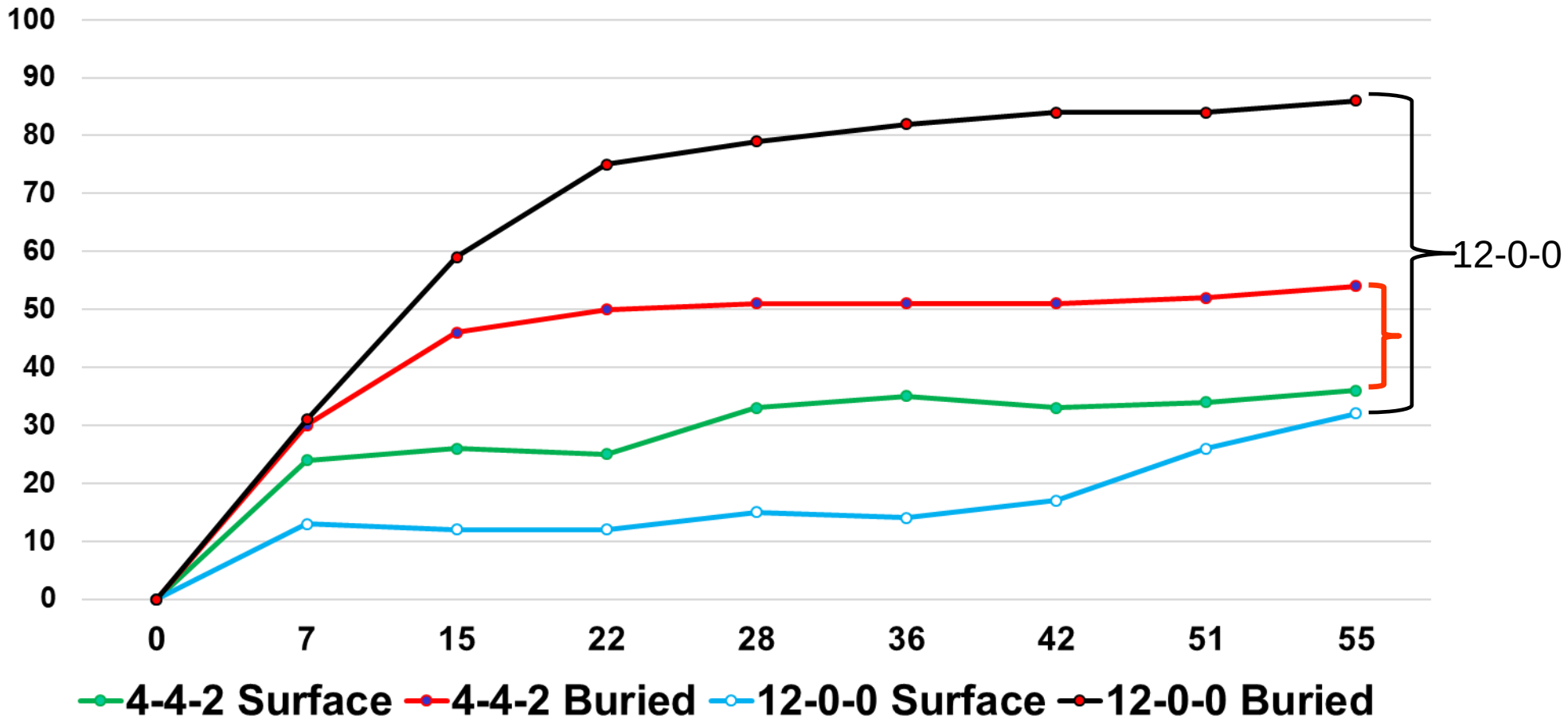
Buried 4-4-2 vs 12-0-0
Percent N Mineralized from Pouches.
High N fertilizers provide more nitrate to plants than low N fertilizers.



Days after Planting Lettuce

From R. Smith, UCCE
Monterey Co. Farm Advisor

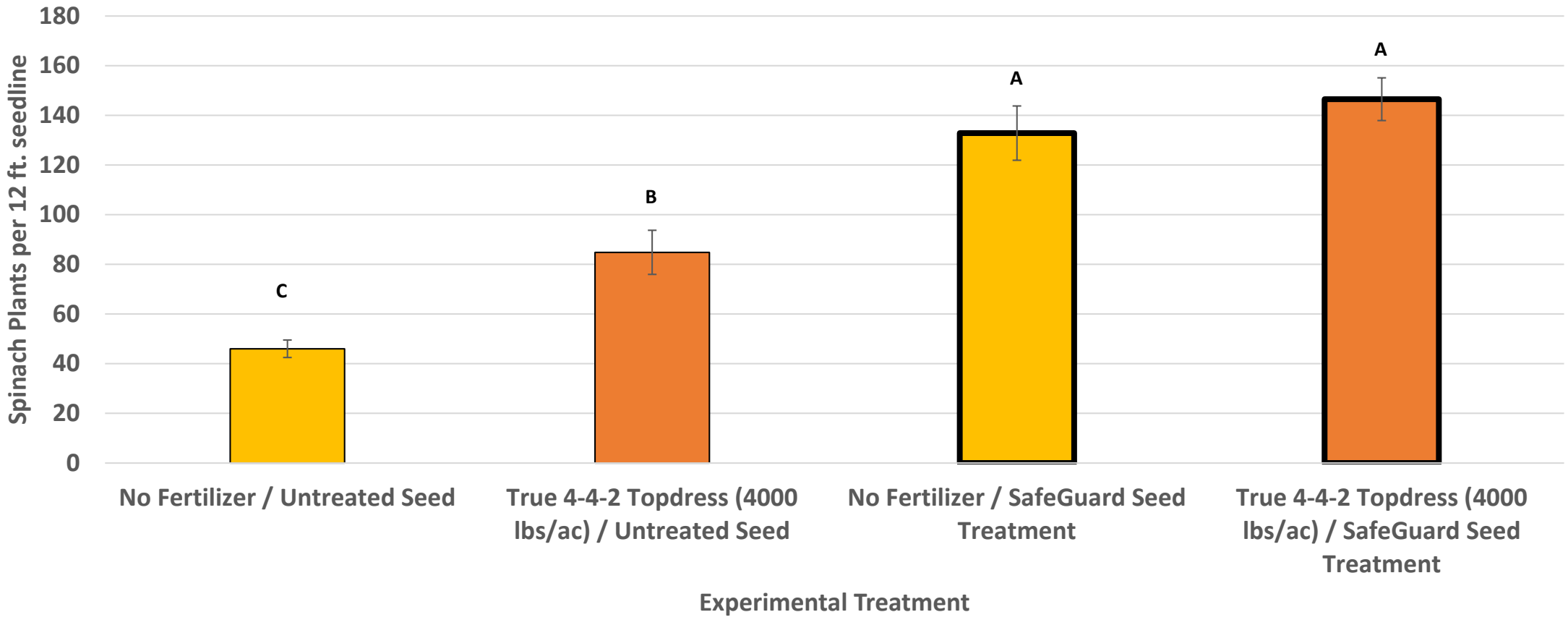
Difference N Release Between 4-4-2 & 12-0-0 in Surface and Buried Placement



Why not always incorporate pelleted fertilizer into soil?

- Pellets left on soil surface release nutrients slowly (pellets dry out more quickly on surface, lower microbial activity between irrigation events).
- To avoid damaging crop during top-dress or side-dress applications.
- To improve spinach stands.
  - Spinach plant population stands were increased when pelleted fertilizer was bed-top applied. Especially true for fields coming out of fallow conditions during first rotation of the season (springtime) with a history of dampening-off disease.
  - New organic spinach seed treatment (ProBio SafeGuard, Germains Seed Technology) has made this practice less important.

The benefits of top-dressed True 4-4-2 fertilizer & SafeGuard Seed Treatment on Spinach Survival in Organic Spinach Production. Replicated-plot field trial in San Benito Co. on ranch with history of high Pythium dampening-off disease and during 1st rotation of the season.



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Large-scale organic leafy vegetable farming

- Cover Crop Types Utilized
  - Indian mustard, white mustard, Ethiopian mustard, kales
  - Cereals such as ryegrass, wheat, triticale, Blends of mustards, cereals, and legumes
  - Sesbania, sudangrass and kales (spring/summer cover crops in Imperial Valley)
- Cover Crop Traits
  - Cover crops must be fast growing and able to close canopy before weeds can become established in cropping cycle.
  - We plant cover crops at high densities similar to our baby crops (>3 million seeds per ac).
  - Research done by Richard Smith, Eric Brennan, and Joji Muramoto helped us learn how to best grow cover crops to improve our organic production.


Indian mustard


Indian mustard

Indian Mustard


Kale Cover Crop


Ryegrass


Ryegrass


Indian Mustard / Ryegrass mix

Sesbania

Benefits of Cover Crops on the Central Coast

1. Cover Crops with high nitrogen content can contribute to cash crop fertility and yields. Cover crops deliver mineral nitrogen to subsequent cash crops if Carbon to Nitrogen ratio is less than 24:1.
2. High density cover crops can suppress weed populations. This occurs by outcompeting germinated weeds as well as suppressing weed seed populations.
3. Some cover crops can reduce soil-borne diseases. Cover crops adds to growers crop rotation, improves microbial activity, may add specific phytochemical to soil that may reduce disease inoculum in soils.

Why aren’t more cover crop acres planted on the Central Coast?

1. Year-around planting dates and harvest dates make it difficult to find good windows to grow cover crops.
   - Row crop wet-dates go from October to August, with harvest dates from March to November.
   - Baby crop wet-dates go from February to October, with harvest dates from March to November.
2. Many grower operations have substantial programs in other growing regions (Yuma, Imperial Valley, San Joaquin Valley, Ventura/Oxnard) and move equipment and staff to these different growing regions throughout the year.
3. Substantial rainfall in late winter/early spring can make it difficult to incorporate cover crops into ground and prepare ground for cash crops.
4. Decomposing cover crops can sometimes lead to short-term increases of certain soil-borne problems (i.e. springtails).
5. In winter production areas (Yuma, Imperial Valley), substantial water is needed to grow cover crops in spring and summer.

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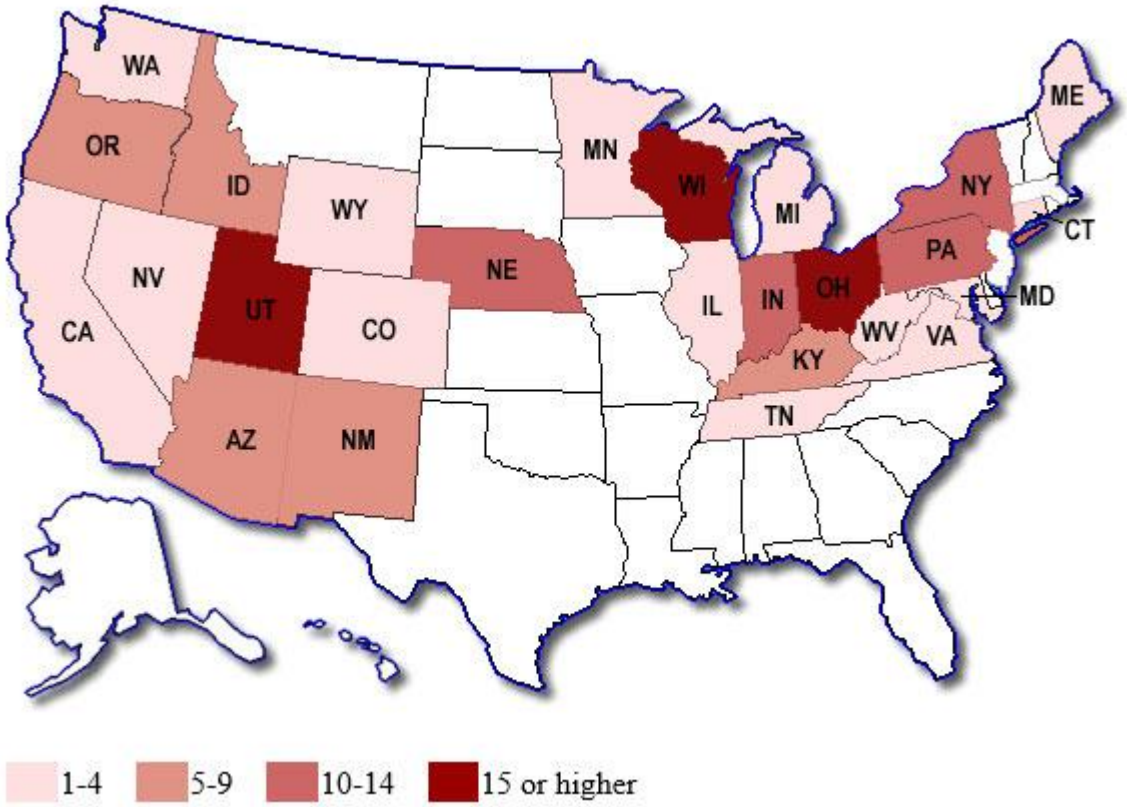
Multistate Outbreak of *E. coli* O157:H7 Infections Linked to Fresh Spinach (FINAL UPDATE)

- Final Case Count Map
  Persons infected with the outbreak strain of *E. coli* O157:H7, by state of residence, as of October 6, 2006 (n=199)



In response to 2006 spinach E. coli outbreak, the Leafy Greens Marketing Agreement (LGMA) was Initiated

- The initiation of the LGMA Metrics had a profound effect on Central Coast farming practices and inputs. This was especially true for organic fertility programs where most inputs are animal-based products.
  - Both Soil Amendments that contain animal products and Non-synthetic Crop Treatments that contain animal products required special scrutiny to ensure that they are not sources for food-borne illness contamination to leafy greens production.
  - Soil amendments and non-synthetic crop treatments that did not meet the strict metrics of the LGMA would no longer be allowed for use on leafy greens.

In response to 2006 spinach E. coli outbreak, the Leafy Greens Marketing Agreement (LGMA) was Initiated

LGMA Metrics

- Manure based compost that is completely composted (properly heated, mixed, documented, tested & microbial activity is below action levels) can be used on leafy greens crops if applied more than 45 days before harvest.

- Soil amendments and non-synthetic crop treatments that are heat treated using a kill-step that has been validated by a recognized authority and microbial activity is below action threshold, can be used in leafy greens production throughout cropping cycle.

- Organic soil amendments and crop treatment manufacturing needed to adopt food safety procedures used in food manufacturing (i.e. Hazard Analysis and Critical Control Point, HACCP).

HACCP Principles

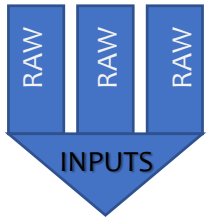
- HACCP is a systematic approach to the identification, evaluation, and control of food safety hazards based on the following seven principles:
- Principle 1: Conduct a hazard analysis.
- Principle 2: Determine the critical control points (CCPs).
- Principle 3: Establish critical limits.
- Principle 4: Establish monitoring procedures.
- Principle 5: Establish corrective actions.
- Principle 6: Establish verification procedures.
- Principle 7: Establish record-keeping and documentation procedures.

True Organic Products is a Leader in Food Safety within the Organic Fertilizer Industry

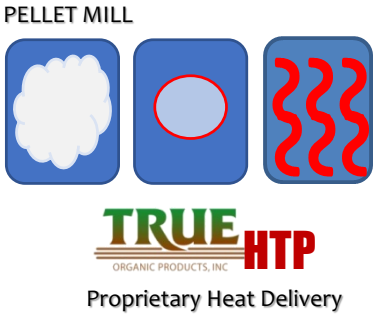
DRY FERTILIZER PROCESS

1. **Raw Material**
2. **Heat Treatment Process**
3. **Representative Sample**
4. **Handling and Storage**
5. **Transportation**

Steps to Food Safety and Quality

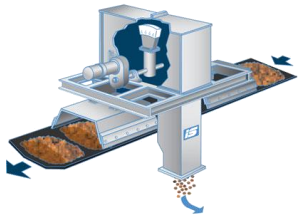


1



Proprietary Heat Delivery

2



PRODUCT Sampling

3

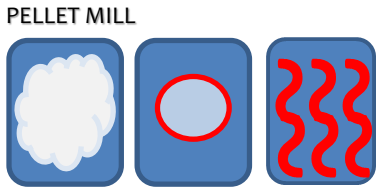
HOLD
&
Release

4

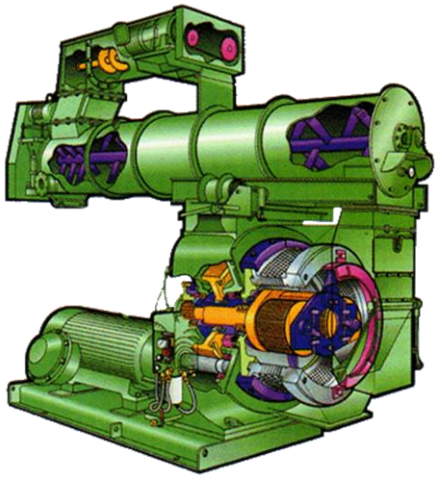
Shipping
&
Transportation

5

Pelleted Fertilizer Validation



TRUE HTP
ORGANIC PRODUCTS, INC
Proprietary Heat Delivery



VALIDATION
val·i·da·tion valəˈdāSH(ə)n/
noun

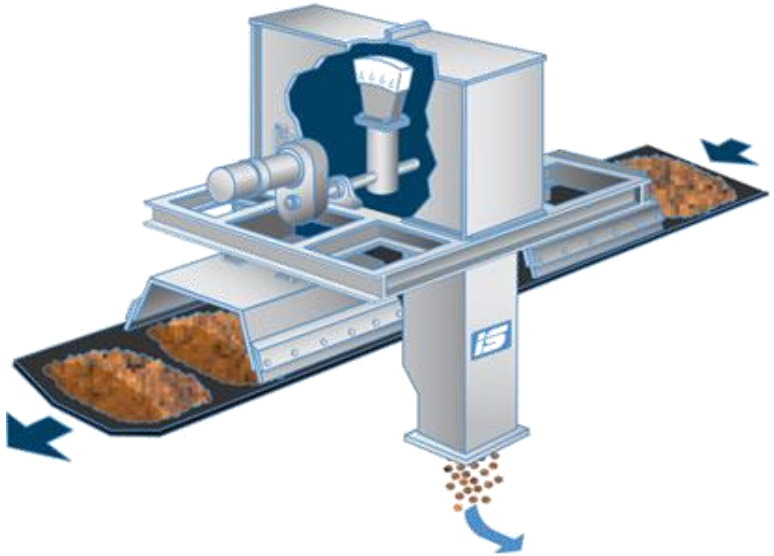
VERIFICATION
ver·i·fi·ca·tion verəfəˈkāSH(ə)n/
noun

Verification and validation are independent procedures that are used together for checking that a product, service, or system meets requirements and specifications and that it fulfills its intended purpose. These are critical components of a quality management system

Part 1
- Validation on equipment
- Salmonella – heat resistant

Part 2
- Various inputs
- Separate equipment
- Salmonella, E. coli O157, Listeria, EHEC, Fecal Coliform

Obtaining a Representative Sample



Autosampler – 1 per 2 min

Documented 3rd Party Training

FINISHED PRODUCT STORAGE

HOLD
&
Release

Bunker probed

Defining the LOT

Examples:

- Time of Production
- Ingredients
- Sanitation

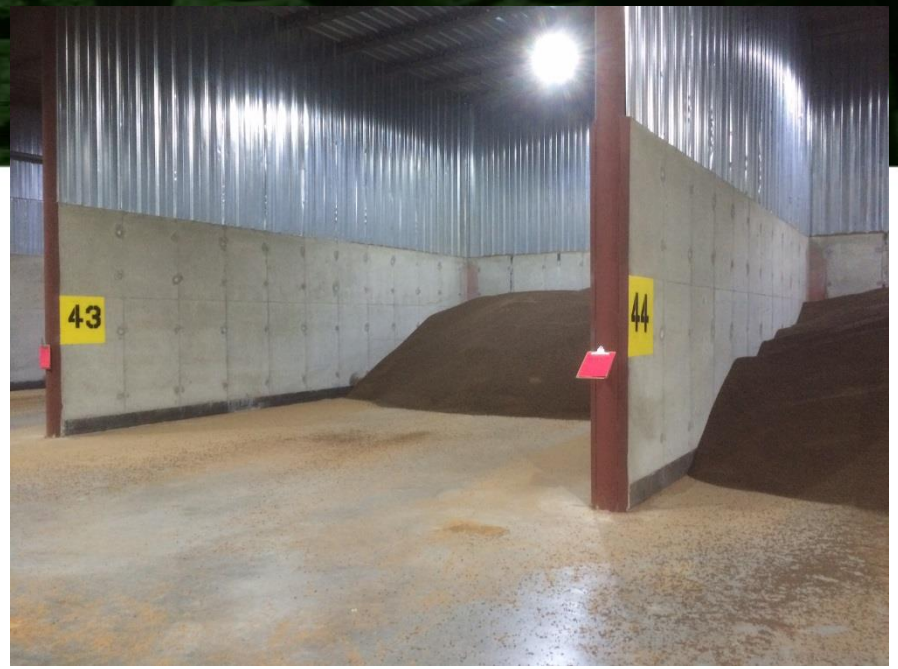
TRUE
Lot Definition

CLEANUP TO CLEANUP

Storage to Protect Integrity

Hold & Release

- Easy to Clean and Sanitize
- include product safety, quality, regulatory compliance and organic integrity



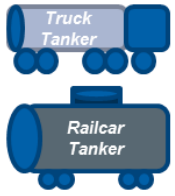
LIQUID FERTILIZER

Raw Material **Representative Sample**

Heat Treatment Process **Handling and Storage**

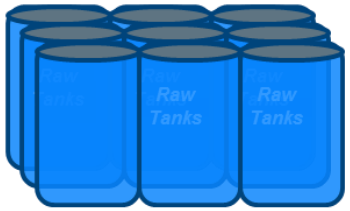
Transportation

Steps to Food Safety and Quality



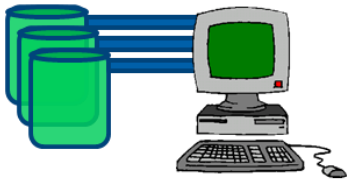
Raw Materials
HOLD
&
Release

1



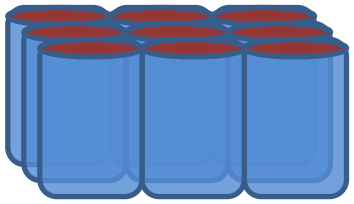
Raw Material Tank Storage

2



TRUE HTP
Validated Heat Treatment

3



Finished Product Tank Storage

4

HOLD
&
Release

5

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In the world of organic farming, if it sounds too good to be true, it is likely to be fraud.

Owner of Kern County Fertilizer Business Sentenced for Organic Fertilizer Fraud.

- Port Organics LLC
  - Agrolizer
  - Marizyme
  - Fishilizer
- Organic products were spiked with synthetic fertilizer.

Former President of Organic Fertilizer Company Pleads Guilty to Fraud in Connection with Selling Synthetic Fertilizer to Organic Farms

Company Grossed Millions Based on Six Years of Fraud

- California Liquid Fertilizer
  - Biolizer XN
- Organic product was spiked with synthetic fertilizer.

Fraud cases sent shockwaves through organic industry and regulatory agencies

Organic growers, shippers, and regulators developed more rigorous programs to scrutinize organic inputs.

- EBF developed ‘approved input list’ that required application process, visits to facilities, audits, etc. before products could be used by EBF suppliers.
- CDFA launched Organic Inputs Materials (OIM) Program.
  - The Organic Input Material (OIM) Program registers fertilizing materials to be used in organic crop and food production. The program is mandated by the Legislature and supported by the industry. Products claiming to be appropriate for use in organic production are verified to comply with the California Fertilizing Materials Law and Regulations and USDA National Organic Program Standards.

Can nitrogen from organic fertilizer be distinguished from nitrogen from conventional fertilizer? Yes

- Examination of nitrogen isotope composition. The $\delta^{15}N$ values of conventional fertilizers are markedly different than those found in organic fertilizer.
- Examination of nitrogen isotope composition can show if synthetic nitrogen has be added to an organic fertilizer.
- Nitrogen isotope composition testing can also differentiate between fossilized, mined nitrogen (i.e. sodium nitrate) and nitrogen originating from animal-based ingredients.
- In many cases, nitrogen isotope composition testing can also be used to verify that an organic crop received organic fertilizer or fraudulently received synthetic fertilizer.

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Rules Proposed for Ag Order 4.0 by Central Coast Regional Water Quality Control Board (CCRWQCB) in limit groundwater protection

- Discharge Limit $A_{FER} + A_{IRR} - R$ = TBD lbs/ac/ranch/year
- Application Limits A_{FER} cannot exceed TBD lbs/ac/crop
- Ranches that repeatedly exceed the numeric discharge limit per the time schedule may be limited or prohibited from applying A_{FER}.
  - A_{FER} is the amount of nitrogen applied in fertilizers, compost, and other amendments
  - A_{IRR} is the amount of nitrogen applied through the irrigation water based on the groundwater nitrate concentration
  - $A_{FER} + A_{IRR}$ = the total amount of nitrogen applied
  - R is the amount of nitrogen removed through harvest, pruning, or other methods, plus the nitrogen sequestered in perennial crop permanent wood

Rules Proposed for Ag Order 4.0 by Central Coast Regional Water Quality Control Board (CCRWQCB) to protect groundwater

Problem for Organic Leafy Green Production:

- In contrast to conventional agriculture where 100% of total nitrogen applied (TNA) will be in mineralized forms during cropping cycle (as NH4 or NO3), only a fraction of total nitrogen applied in organic fertilizer and organic amendments by organic growers is converted to mineralized nitrogen during the cropping cycle.
- Mineralization rates of organic amendments and fertilizers vary greatly but are generally below 60% in laboratory studies.
- **This will mean organic growers will have to grow crops with 40-70% less mineralized nitrogen than conventional growers.**
- **Ag Order 4.0 will disproportionally penalize organic farming.**

Rules Proposed for Ag Order 4.0 by Central Coast Regional Water Quality Control Board (CCRWQCB) to protect groundwater

As proposed, Ag Order 4.0 will disproportionally penalize organic farming**:**

- The Ag Order 4.0 constraint on organic farming fertility programs could be very detrimental to organic farming on the Central Coast.
- If fertility rates are cut by 40-60%, organic crop yields and quality would be devastated, and organic leafy greens farming may not be financially viable.
- Indeed, this may force some growers to go from organic production back to conventional production due to this Ag Order 4.0 constraint.

Solutions to help promote organic farming and meet rules proposed for Ag Order 4.0

Proposed Solution:

1. Add a mineralization coefficient multiplied by the pounds of nitrogen applied for a specific organic fertilizer:
    - $M*A_{FER}$= mineralization rate multiplied by the total nitrogen applied in fertilizer.
    - For each organic fertilizer, growers would use a scientifically measured mineralization rate (M) determined by UC fertility specialists.
2. Encourage management practices that reduce residual nitrate remaining in the soil at the end of the growing season.
    - Winter cover cropping (October-March) can reduce nitrate leaching on average by 75% in lettuce production on the central coast (Smith et al. 2005).
    - An autumn application of high C:N ratio amendment (C:N ratio greater than 50:1) has the potential to reduce nitrate leaching by immobilizing residual soil nitrate, potentially preventing >75% soil nitrate from leaching (Muramoto et al. 2019).

Solutions to help promote organic farming and meet rules proposed for Ag Order 4.0

Proposed Solution:

3. CCOF (California Certified Organic Farmers) wants to create a water quality enhancement program that would supplement the existing organic certification and qualify an operation for **the lowest tier of regulation**. The certification would verify additional, quantifiable standards focused on nutrient management and erosion control.

Case study evaluating different organic fertilizer rates (True 8-5-1), organic spinach production, Santa Clara County

Treatments:

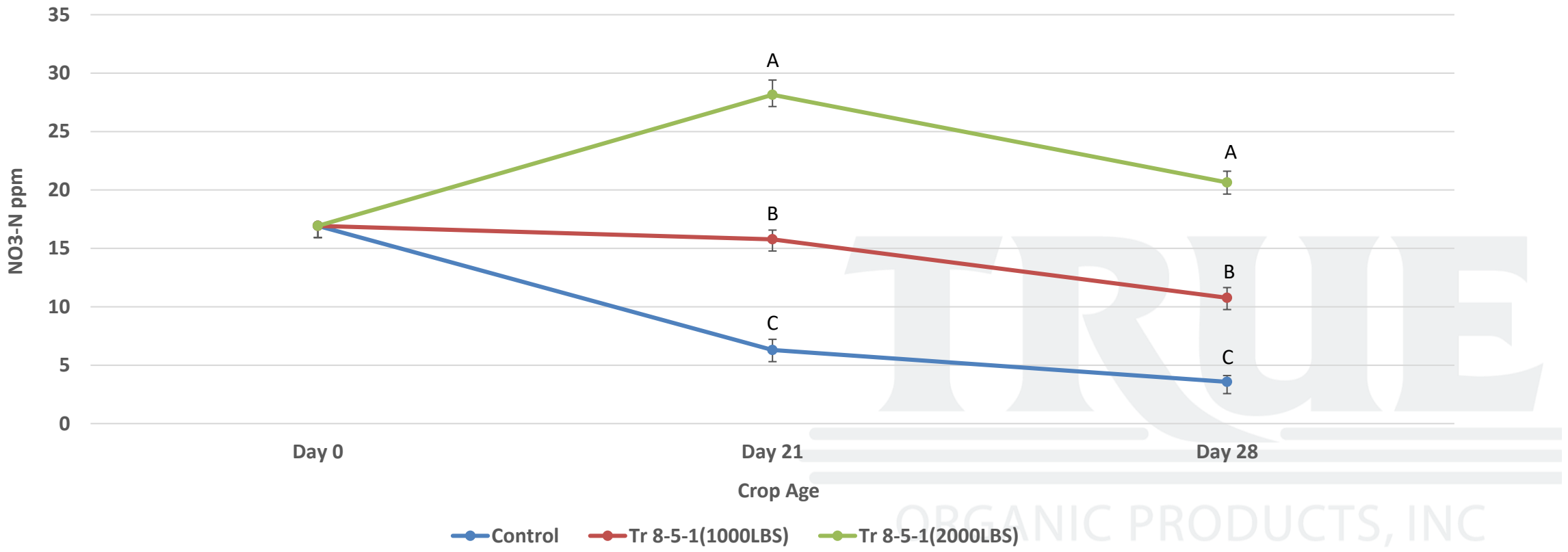
1. Untreated Control
2. TRUE 8-5-1 Low Rate (1000 lbs/ac True 8-5-1; 80 lbs total N). Incorporated into soil.
3. TRUE 8-5-1 Standard Rate (2000 lbs/ac True 8-5-1; 160 lbs total N). Incorporated into soil.

Conditions:

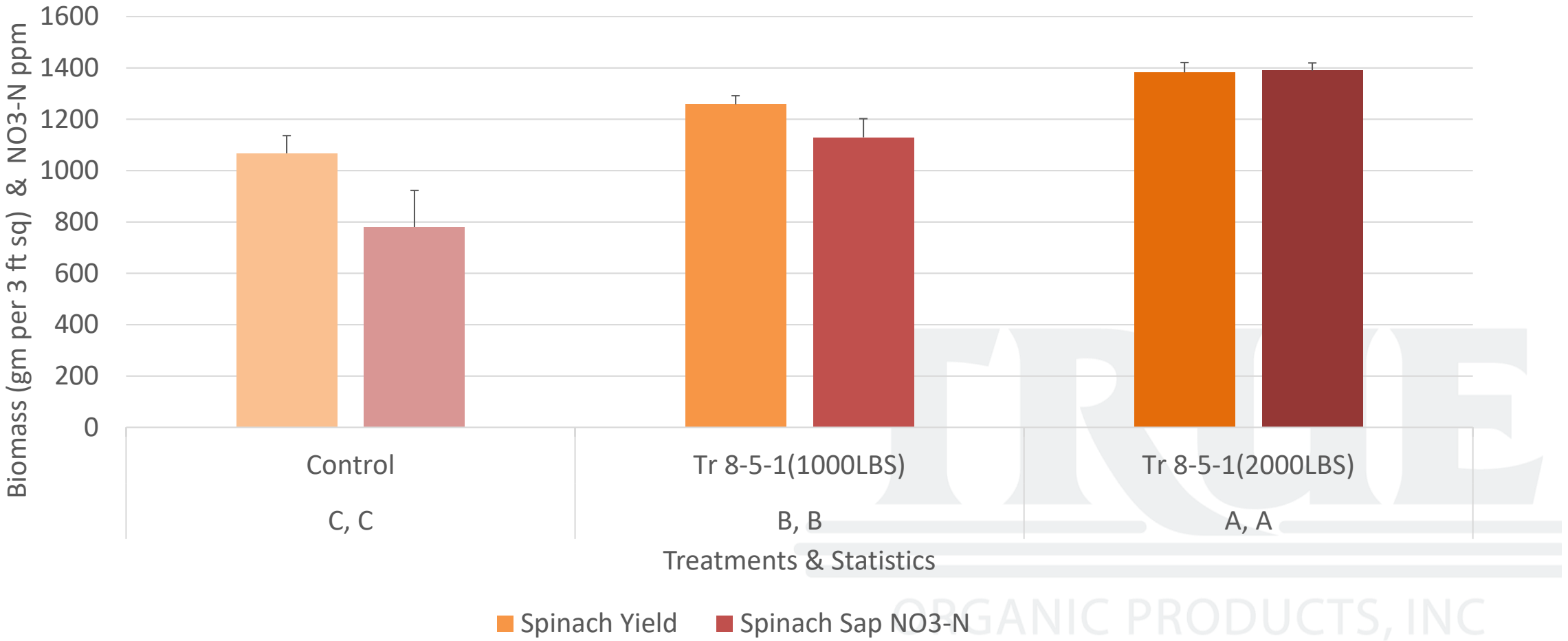
- Fall productions (moderate conditions).
- Sandy loam soil, good irrigation water, good residual NO3-N in soil (17 ppm)
- Irrigation water with 2 ppm NO3-N (low contribution).
- Spinach field had very good fertility and was highly uniform.
- Small-replicated, randomized-block design (plot: 20 ft. x 20 ft., n = 24).

- KEY POINT: Based on UC Recommendations, Preplant soil NO3-N levels (~68 lbs N/ac) and Low Rate True 8-5-1 (80 lbs N/ac) should deliver 100% of total yield potential.

The different fertilizer rates delivered significantly different soil NO3-N levels compared to the untreated control. Only the 2000 lb/ac rate True 8-5-1 delivered adequate levels of NO3-N throughout cropping cycle (>20 ppm).



The different fertilizer rates delivered significantly greater spinach yields and spinach plant sap NO3-N levels compared to the untreated control. The 2000 lb/ac rate True 8-5-1 delivered significantly greater yields and levels of sap NO3-N compared to 1000 lb/ac rate True 8-5-1 (Superior performance).



Case study evaluating different organic fertilizer rates (True 8-5-1), organic spinach production, Santa Clara County

Conclusions:

- Based on UC Recommendations, preplant soil NO3-N levels (~68 lbs N/ac) and Low Rate True 8-5-1 (80 lbs N/ac) should have deliver 100% of total yield potential.

- However, even though growing conditions were optimal for spinach fertility (third crop rotation, October harvest date, warm-short days & long-cool nights), we still observed significant increase in spinach yield (10%) and spinach quality (increased plant sap NO3-N = increased chlorophyll levels = increased shelf life) at higher fertilizer rate (True 8-5-1 [160 lbs. N/ac]).
- Organic fertility management is complex and based on many variables.

- More research is needed in organic fertility management before organic fertility programs are dramatically changed by new Ag Order 4.0 rules.

True Research and Development Team

True Research & Development Team

Our full-time research and development team are evaluating new inputs and constantly gathering new data through field, greenhouse and laboratory trials to further our knowledge and allow True to create only the best organic fertilizers possible, for every crop

- Charles Grove, Ph.D.
  - Product development
  - Scale up
  - Formulation
  - Optimization
- Ehsan Toosi, Ph.D.
  - Soil health
  - Soil Microbiology
  - Soil Chemistry
  - Soil Physics
- Ramy Colfer, Ph.D.
  - 18 years organic field experience and organic agricultural research
  - Farming pest management – 12,000 annual acres organic crops
  - Variety selection and seed purchasing of organic crops
  - Soil monitoring and fertility management

True Research & Development Team

Dry Pelleted Fertilizer:

1. Evaluation of how different pellet formulations deliver plant nutrients to crops to a wide range of cropping systems.
2. Examine the use of new organic ingredients to broaden the performance of dry pelleted fertilizer to improve soil quality, nutrient availability, and crop performance.
3. Examine how different dry pelleted fertilizers affect soil microbial activity, soil health, and other important variables (i.e. soil-borne plant pathogen inoculum levels).

True Research & Development Team

Organic Liquid Fertilizers:

1. To develop new techniques and use new materials to make True organic liquid fertilizers highly effective at quickly delivering plant nutrients.
2. To make organic liquid fertilizers highly effective at being delivered through drip irrigation systems (where minimal nutrients is lost) by increasing water solubility, reducing particle size, and improving shelf stability.
3. To determine how components of True liquid fertilizers (like labial carbon) affect soil microbial activity, soil health, and plant nutrient uptake.

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