PLANT NUTRITION – past, present and future

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November 1, 2017

PAST

PRESENT

FUTURE

PAST

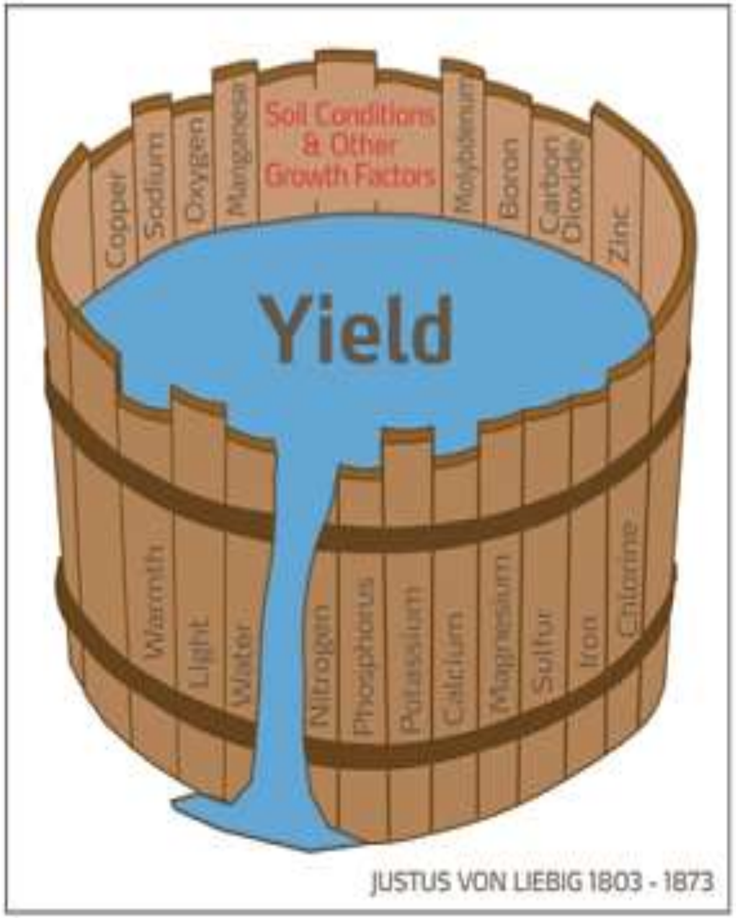
- organic fertilizers
- nutrients returned to soil with crop residues and manure
- challenge: yields limited by nutrient deficiency, non-optimal timing of availability and nutrient imbalance

PAST

144 YEARS AGO

Justus von Liebig's "Law of the Minimum" published in 1873

"If one growth factor/nutrient is deficient, plant growth is limited, even if all other vital factors/nutrients are adequate...plant growth is improved by increasing the supply of the deficient factor/nutrient"



PAST

18 YEARS AGO

Nutrient Cycling in Agroecosystems 71: 177–190, 2005.
DOI 10.1007/s10705-004-2214-7

Methylene urea as a slow-release nitrogen source for processing tomatoes

Marja E. Koivunen* and William R. Horwath

2-year field trial on processing tomato fb wheat at UC Davis

Main question:

- Can N use efficiency of processing tomato be improved with a slow-release N fertilizer (methylene urea/urea formaldehyde)

Variables:

Urea vs. methylene urea
Fallow vs. Cover crop
Seeded vs. transplanted tomato

Parameters:

Yield quantity and quality
N uptake by crop
Fertilizer N use efficiency using ^{15}N technique
Soil ^{15}N (nitrate and biomass N) fall/spring
Residual N effect on wheat grown w/o fertilizer

RESULTS (Koivunen and Horwath 2005)

- No difference in tomato yield quantity and quality
- Deep soil core samples taken to 200-cm (6.5 feet) depth after the first transplanted tomato crop in fall 1999 showed high contents of fertilizer-derived NO_3-N in the urea-fertilized soil. The following spring, soil $^{15}NO_3$-N content was significantly lower in these plots (note: all ^{15}N plots were left fallow during the winter)

Table 5. ^{15}N recovery (%) in a soil profile (0–200 cm) measured in microplots at times indicated in the table.

	Seeded block, $^{15}NO_3$-N		Transplanted block, $^{15}NO_3$-N			
	Fall 2000 (%)	Spring 2001 (%)	Fall 1999 (%)	Spring 2000 (%)	Fall 2000 (%)	Spring 2001 (%)
Furea	4.1a	0.1	42.4	10.7b	1.8	0.1
FuMU	1.8b	0.3	8.7	23.2a	2.5	0.3
CCurea	4.2a	0.1	37.1	4.5b	0.1	0.1
CCuMU	5.7a	0.4	17.0	5.9b	0.3	0.2
Source of variation						
Fertilizer (FE)	**	**	***	**	**	**
Management (M)	NS	NS	NS	NS	NS	NS
FE × M	**	NS	NS	**	NS	NS

NS $P > 0.05$; *$0.05 \geq P > 0.01$; **$0.01 \geq P > 0.001$; ***$0.001 \geq P$.

F – fallow
CC – cover crop
uMU – 50:50 mixture of urea and methylene urea

RESULTS (Koivunen and Horwath 2005)

Fertilizer N use efficiency

Table 3. ^{15}N recovery (%) in the plant biomass and soil.

	^{15}N recovery								
	Seeded block				Transplanted block				
	Tomato 00 (%)	Wheat 00/01 (%)	Soil 01 (%)	Total (%)	Tomato 99 (%)	Tomato 00 (%)	Wheat 00/01 (%)	Soil 01 (%)	Total (%)
Furea	40.0ab	17.5	17.4	74.9b	40.0	13.2	6.2	14.0	73.4a
FuMU	42.7ab	22.4	31.8	96.9a	31.5	17.6	5.9	13.6	68.6ab
CCurea	44.6a	9.0	21.8	75.4b	33.7	5.6	1.6	9.7	50.6b
CCuMU	32.4b	16.8	28.0	77.2b	44.8	5.8	2.0	10.7	63.3ab
Source of variation									
Fertilizer (FE)	*	*	**	**	NS	NS	NS	NS	*
Management (M)	NS	NS	NS	NS	NS	***	***	*	*
FE × M	***	NS	NS	*	NS	NS	NS	NS	***

For plant recovery, the total ^{15}N in aboveground plant biomass was included. For determination of the ^{15}N in soil at the end of the 2-year study, soil samples (0–30 cm) were analyzed for total ^{15}N content. Letters in columns indicate differences between treatment means according to Tukey's protected LSD test at $P \leq 0.05$. Letters are indicating differences only in cases where the interaction (F × M) is statistically significant.
NS $P > 0.05$; *$0.05 \geq P > 0.01$; **$0.01 \geq P > 0.001$; ***$0.001 \geq P$.

→ N use efficiency was not significantly improved with slow-release N

Lesson learned #1. Nitrogen uptake curve for tomato

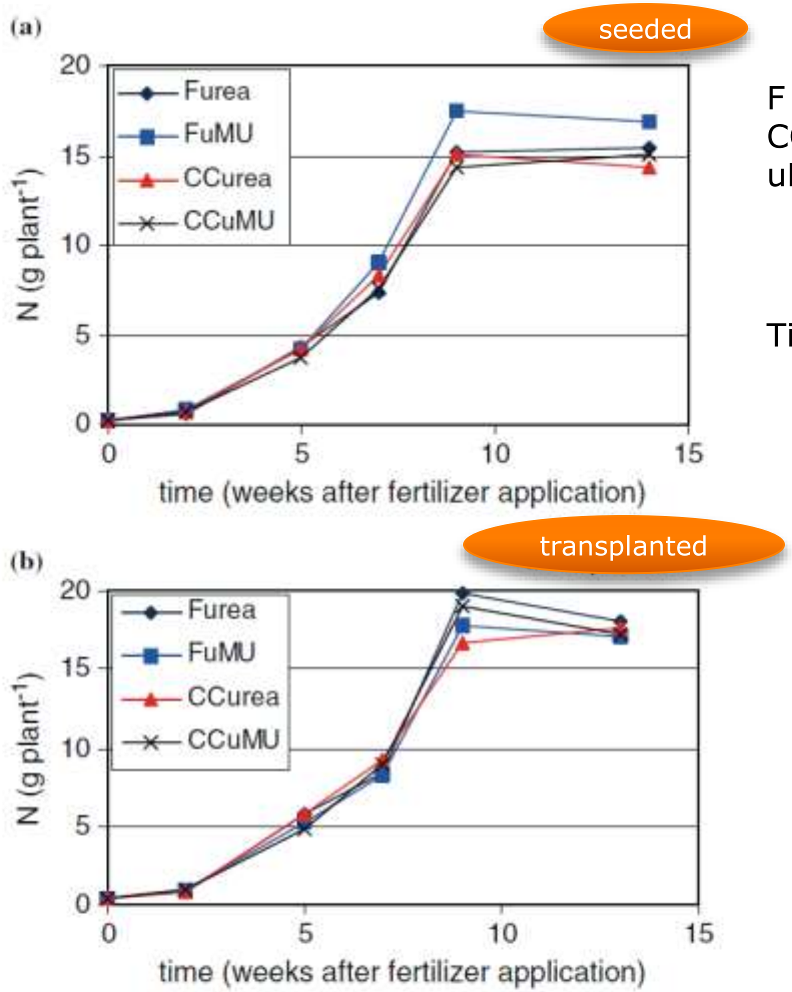


Figure 1. N uptake (g plant^{-1}) measured during the growing season in 1999 for (a) a seeded and (b) a transplanted tomato variety (Heinz 8892).

F – fallow
CC – cover crop
uMU – 50:50 mixture of urea and methylene urea

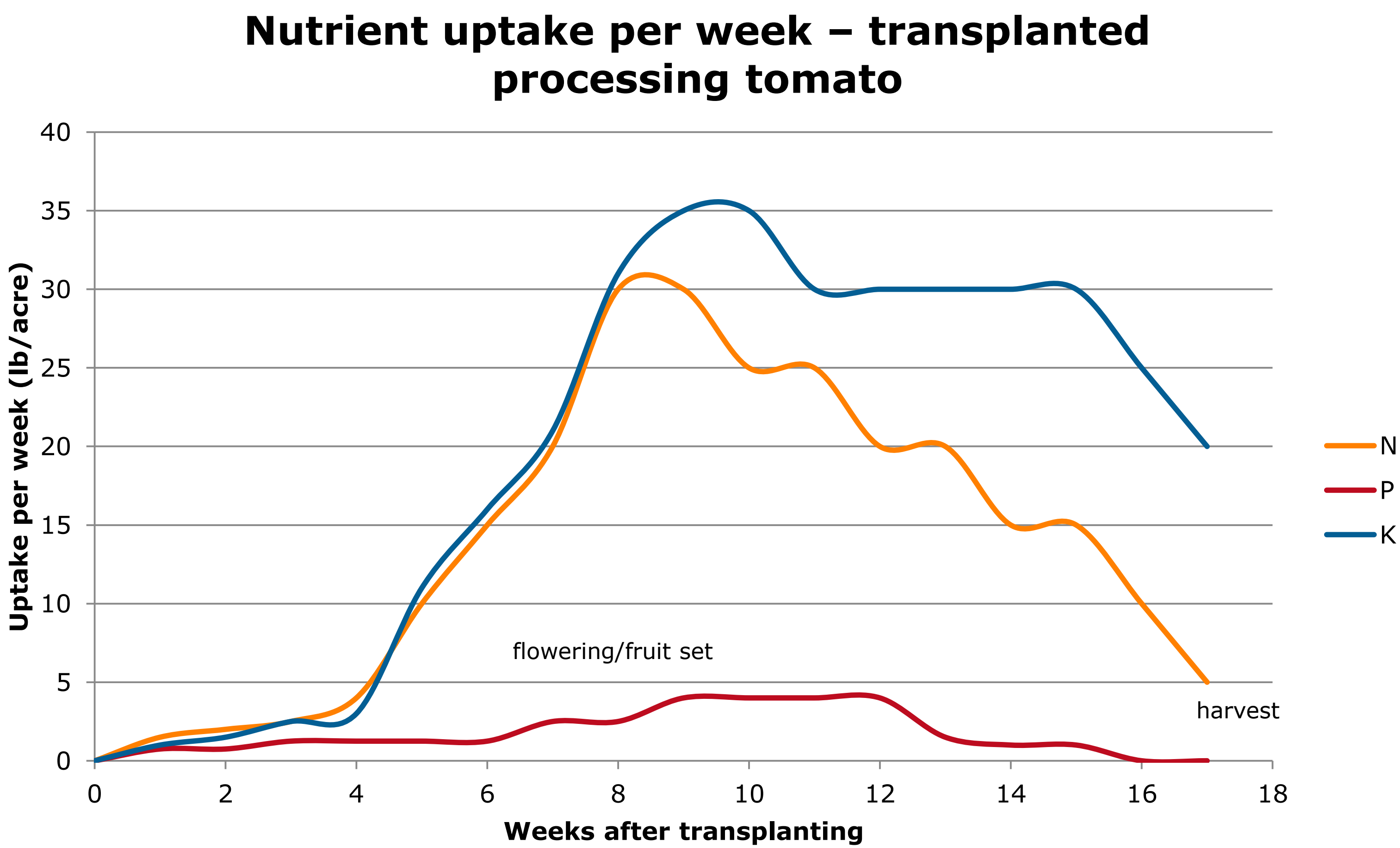
Time 0 sampling: 7 weeks after seeding or
3 weeks after transplanting

N content in the above-ground biomass was generally higher in the transplanted than seeded tomato plants

The plant N content **did not significantly change** between the last sampling (16 weeks after seeding or 12 weeks after transplanting) and harvest

PRESENT

Application in field fertigation programs



Hypothetical nutrient uptake curve for processing tomato based on field data and fertigation programs designed for greenhouse tomatoes

Lesson learned #2. Effect of cover crop on soil properties and nitrogen management

- Increased organic matter content
- Increased soil microbial activity
- Increased storage of N in the microbial biomass
- Decreased bulk density
- Increased infiltration rate

→ Improved Soil Health

2015 International Year of Soils

Improving Soil Health

- Long-term Thinking and Strategy

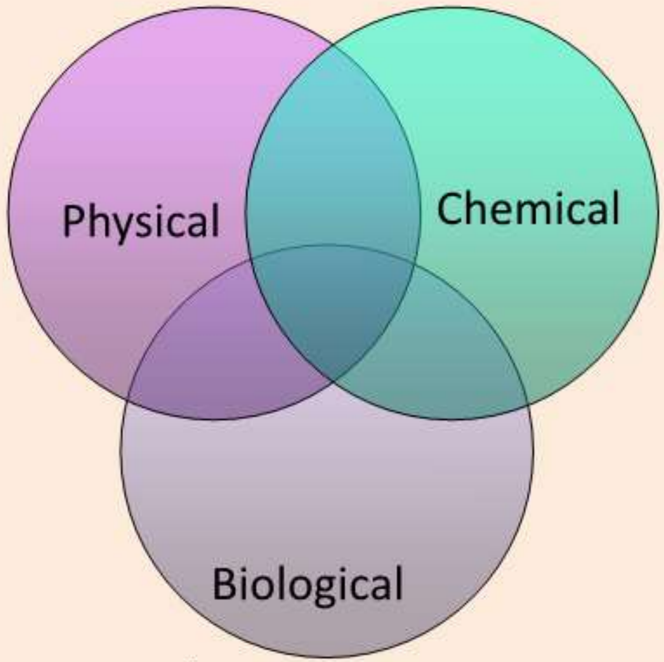
Basic Methods (Toolbox)

- **Tillage Management (Reducing tillage)**
- **Cover Cropping**
- **Crop Rotation**
- **Organic Matter Addition & Management**

PRESENT

Soil Health Indicators

- Bulk density
- Penetration resistance
- Aggregate stability
- Water infiltration rate
- Water holding capacity
- Pore size distribution



- Cation exchange capacity
- N, P, K
- Salinity
- Micronutrients
- [Toxins, pollutants]

- Soil disease suppressive capacity
- Beneficial and pathogenic nematodes, [other pathogens]
- N mineralization rate (PMN)

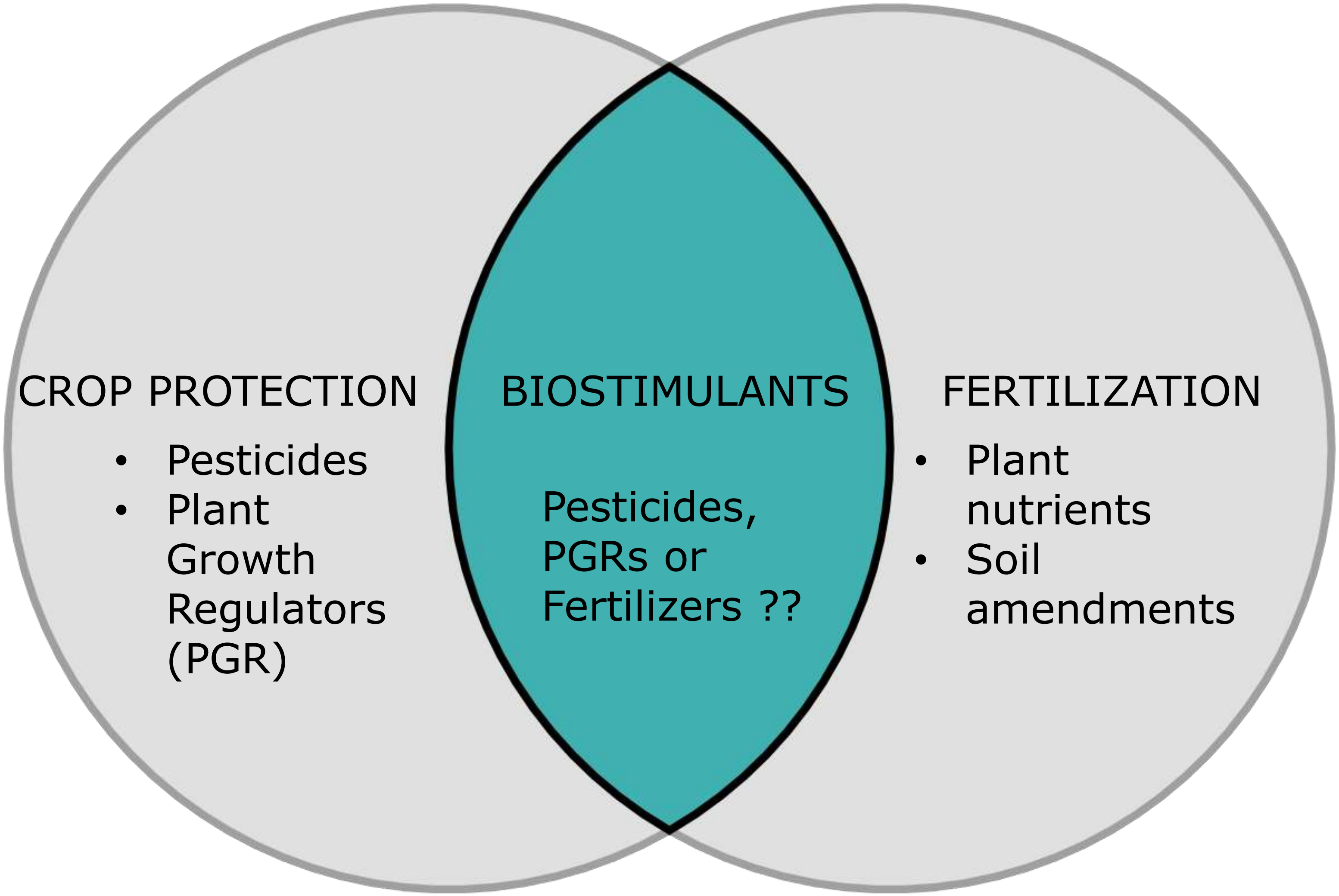
- Decomposition rate
- Respiration rate
- Earthworm counts
- *% OM*
- *"Active" C, N in OM*

PRESENT

- mineral fertilizers, specialty fertilizers, improved application techniques and timing (4R principle)
- plant nutrition/fertilizer use based on crop requirements and soil nutrient content
- focus on improved nutrient efficiency and decreased losses in the environment
- new appreciation of soil organic matter and soil health

FUTURE

BIOSTIMULANTS – WHAT ARE THEY?



BIOSTIMULANT

Plant Biostimulant means a material which contains substance(s) and/or microorganisms whose function when applied to plants or the rhizosphere is to stimulate natural processes to benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress, and/or crop quality, independently of its nutrient content

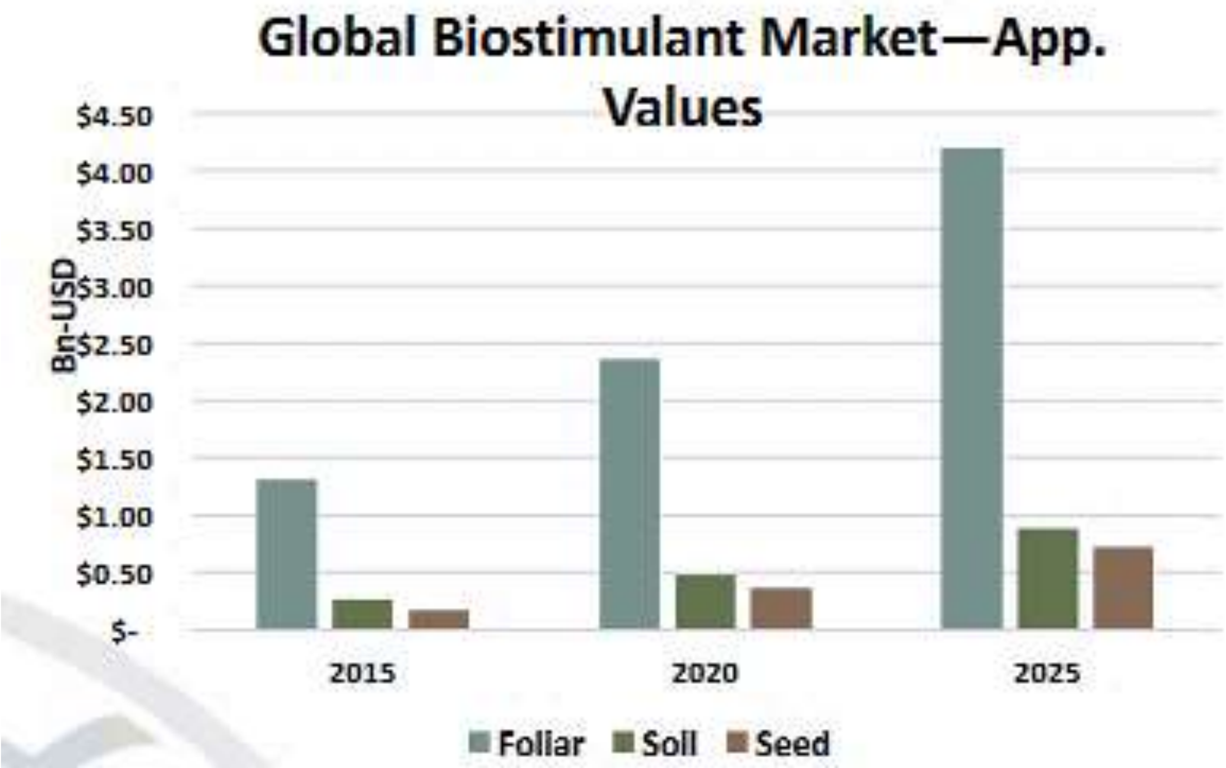
European Biostimulant Industry Consortium (EBIC)

EXAMPLES:

- Seaweed extracts
- Microbial inoculants
- Protein hydrolysates
- Humic and Fulvic acids
- Amino acids

Beneficial Substance: Means any substance or compound other than primary, secondary, and micro plant nutrients that can be demonstrated by scientific research to be beneficial to one or more species of plants, when applied exogenously. (AAPFCO 2007)

FUTURE

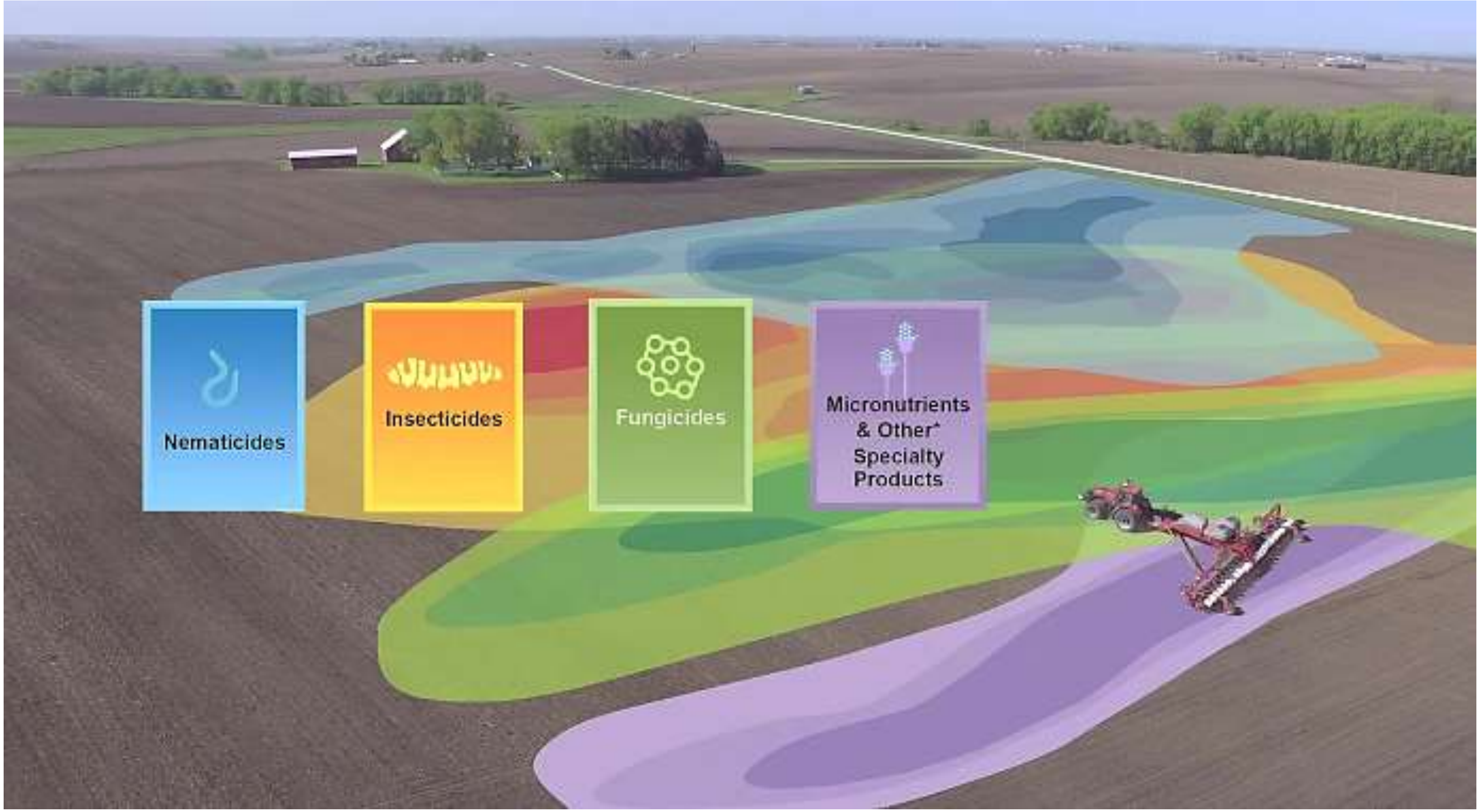


DunhamTrimmer
International Bio Intelligence
2017

Unclear regulatory environment is slowing down the market growth in the US

FUTURE

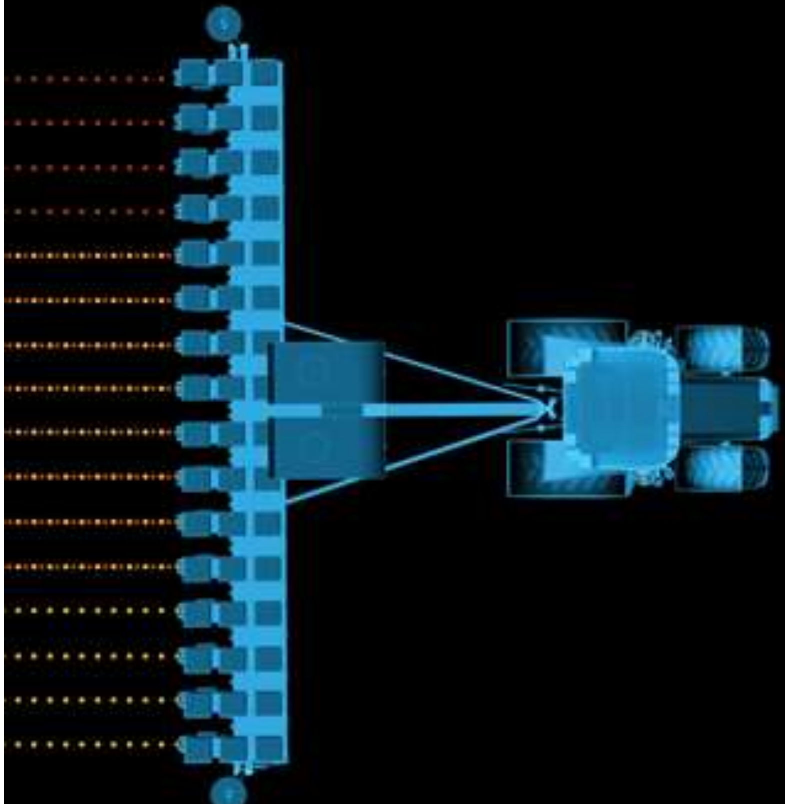
Site-specific prescription application of fertilizers, pesticides and biostimulants



http://american-vanguard.com/NewsMedia/InvestorVideo/SIMPASVideoPresentation/tabid/355/Default.aspx

FUTURE

Multi-Product Application



- Micronutrients
- Biologicals
- Nematicides
- Fungicides
- Insecticides

- iPad®
- Wireless
- Works with all brands of equipment

AMVAC

SIMPAS™

FUTURE

- combination of inorganic and organic nutrient sources
- site-specific and variable-rate application techniques
- focus is shifted from the quantity and quality of plant nutrients to enhanced nutrient uptake by the plant

PAST

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- nutrients returned to soil with crop residues and manure
- challenge: yields limited by nutrient deficiency, non-optimal timing of availability and nutrient imbalance

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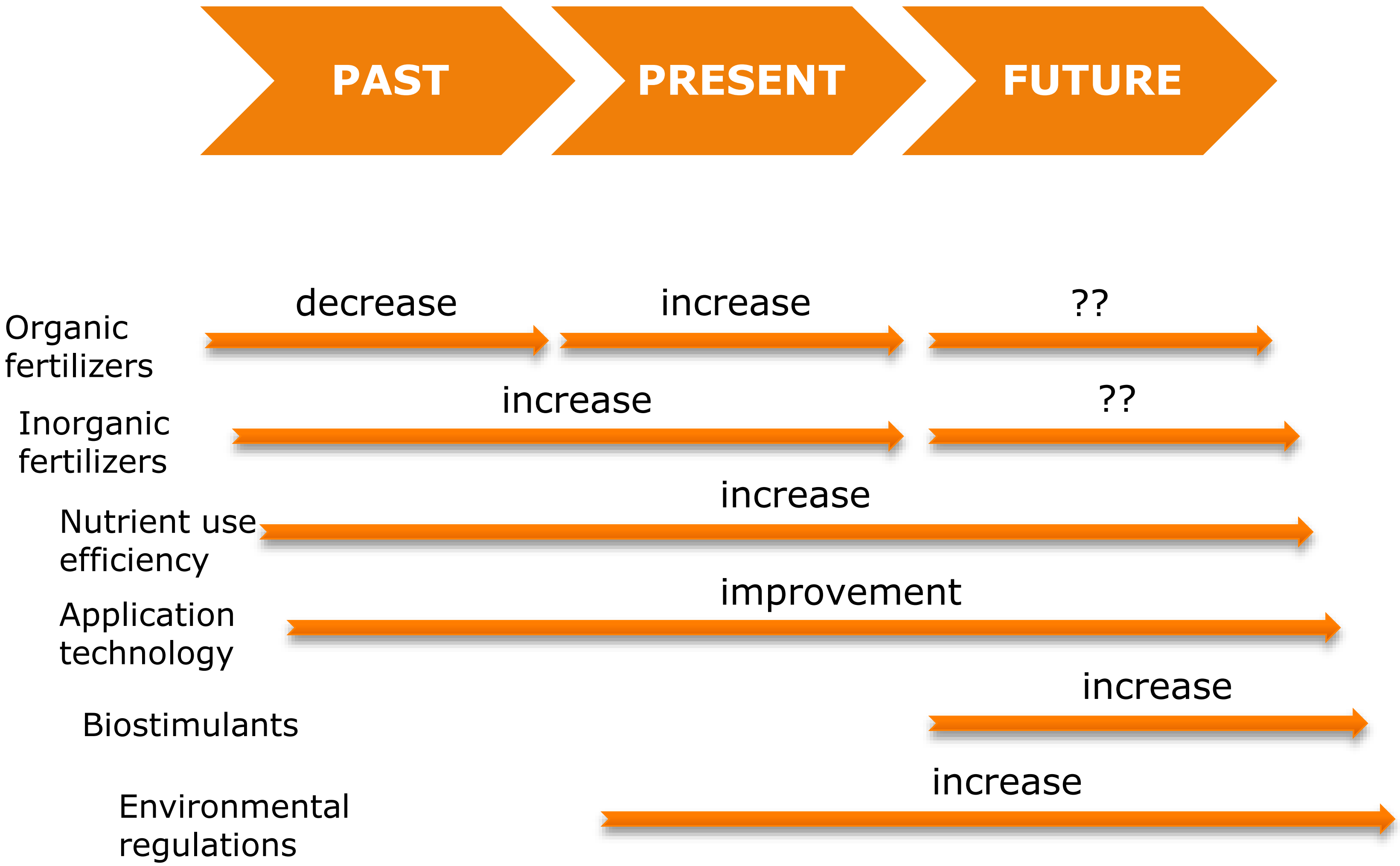
PAST
PRESENT
FUTURE
Organic fertilizers
decrease
increase
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Inorganic fertilizers
increase
??
Nutrient use efficiency
increase
Application technology
improvement
Biostimulants
increase
Environmental regulations
increase

Thank You

Questions?