

The 6th CIGR International Conference
Section V: System Management
(Jeju, South Korea)

System Management for Digital Agriculture Using Two-Level Control

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Precision Agriculture and Sensor Systems (PASS) Research Team

- Development of Proximal Soil and Plant Sensing Systems
- Geospatial Data Processing and Management
- Practical Implementation of Precision Agriculture



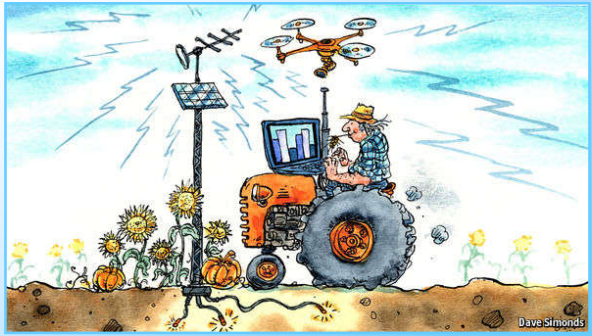

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Future of Agriculture



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Traditions versus Innovations




Dave Simmonds

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Precision Agriculture

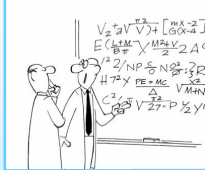

Precision Agriculture is a management strategy that gathers, processes and analyzes temporal, spatial and individual plant and animal data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production.



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Precision Agriculture

It's not Rocket Science!
It's much more actually....





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Precision Agriculture is **not** ...

A set of technologies that could do magic



- Resolve generic production problems
- Transform stones into fertile soil
- Make it rain more or less
- Make a bad machine do a good job
- Change the value of currency



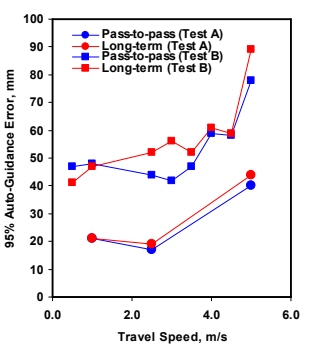
However, it can help diagnose production problems and direct towards potential solutions

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GNSS-Based Auto-Guidance



ISO 12188-2



Travel Speed (m/s)	Pass-to-pass (Test A)	Long-term (Test A)	Pass-to-pass (Test B)	Long-term (Test B)
0.0	45	45	45	45
1.0	20	20	20	20
2.0	18	18	18	18
3.0	45	45	45	45
4.0	55	55	55	55
5.0	40	40	40	40
6.0	85	85	85	85

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Computer Vision Guidance

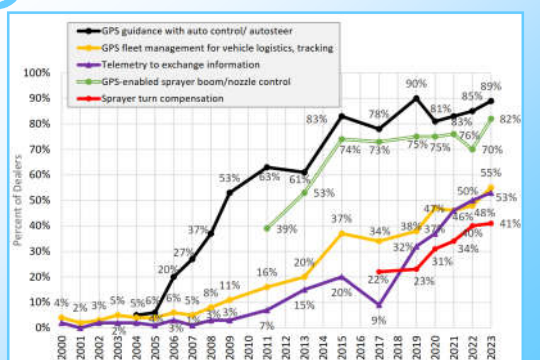
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Planting with VRT Seeding and Individual Unit Control




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Precision Agriculture Adoption

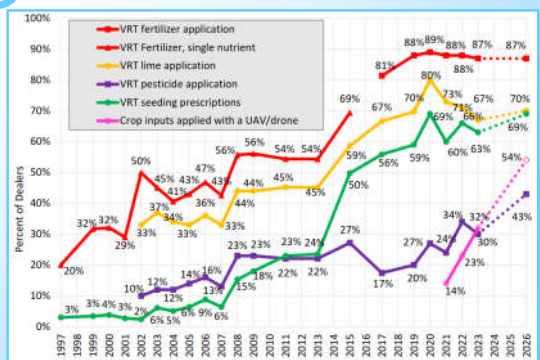


Year	GPS guidance with auto control/autosteer	GPS fleet management for vehicle logistics, tracking	Telemetry to exchange information	GPS-enabled sprayer boom/nozzle control	Sprayer turn compensation
2000	0%	4%	2%	3%	5%
2001	0%	4%	3%	3%	5%
2002	0%	4%	3%	3%	5%
2003	0%	4%	3%	3%	5%
2004	0%	4%	3%	3%	5%
2005	0%	4%	3%	3%	5%
2006	0%	4%	3%	3%	5%
2007	0%	4%	3%	3%	5%
2008	0%	4%	3%	3%	5%
2009	0%	4%	3%	3%	5%
2010	0%	4%	3%	3%	5%
2011	0%	4%	3%	3%	5%
2012	0%	4%	3%	3%	5%
2013	0%	4%	3%	3%	5%
2014	0%	4%	3%	3%	5%
2015	0%	4%	3%	3%	5%
2016	0%	4%	3%	3%	5%
2017	0%	4%	3%	3%	5%
2018	0%	4%	3%	3%	5%
2019	0%	4%	3%	3%	5%
2020	0%	4%	3%	3%	5%
2021	0%	4%	3%	3%	5%
2022	0%	4%	3%	3%	5%
2023	0%	4%	3%	3%	5%

Purdue University 2023 Precision Agricultural Services Dealership Survey

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Adoption of Variable Rate Technologies



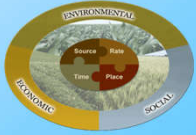
Year	VRT fertilizer application	VRT Fertilizer, single nutrient	VRT lime application	VRT pesticide application	VRT seeding prescriptions	Crop inputs applied with a UAV/drone
1997	0%	0%	0%	0%	0%	0%
1998	0%	0%	0%	0%	0%	0%
1999	0%	0%	0%	0%	0%	0%
2000	0%	0%	0%	0%	0%	0%
2001	0%	0%	0%	0%	0%	0%
2002	0%	0%	0%	0%	0%	0%
2003	0%	0%	0%	0%	0%	0%
2004	0%	0%	0%	0%	0%	0%
2005	0%	0%	0%	0%	0%	0%
2006	0%	0%	0%	0%	0%	0%
2007	0%	0%	0%	0%	0%	0%
2008	0%	0%	0%	0%	0%	0%
2009	0%	0%	0%	0%	0%	0%
2010	0%	0%	0%	0%	0%	0%
2011	0%	0%	0%	0%	0%	0%
2012	0%	0%	0%	0%	0%	0%
2013	0%	0%	0%	0%	0%	0%
2014	0%	0%	0%	0%	0%	0%
2015	0%	0%	0%	0%	0%	0%
2016	0%	0%	0%	0%	0%	0%
2017	0%	0%	0%	0%	0%	0%
2018	0%	0%	0%	0%	0%	0%
2019	0%	0%	0%	0%	0%	0%
2020	0%	0%	0%	0%	0%	0%
2021	0%	0%	0%	0%	0%	0%
2022	0%	0%	0%	0%	0%	0%
2023	0%	0%	0%	0%	0%	0%
2024	0%	0%	0%	0%	0%	0%
2025	0%	0%	0%	0%	0%	0%
2026	0%	0%	0%	0%	0%	0%

Purdue University 2023 Precision Agricultural Services Dealership Survey

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Variable Rate Technology



- It is obvious that skipping, overlapping, or placing agricultural inputs outside the cropping area should be avoided
- 4R nutrient stewardship
 - Right fertilizer source
 - Right rate
 - Right time
 - Right place
 - Right rotation (+1R)
 - Right tillage (+1R)



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Two-Level Control

- Advisory service to define site-specific needs
 - Cultivar and soil
 - Weather and economics
 - Risk management
- Variable rate technology
 - Distinct difference in site-specific needs
 - Means to recognize the variability
 - Responsive application tools

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Variable Rate Technology

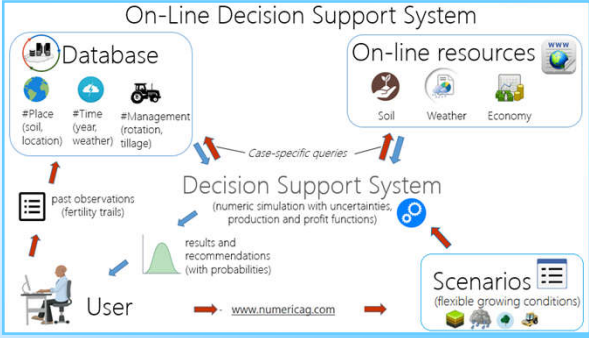


VRT seeding
VRT application of UAN
VRT application of P, K and S

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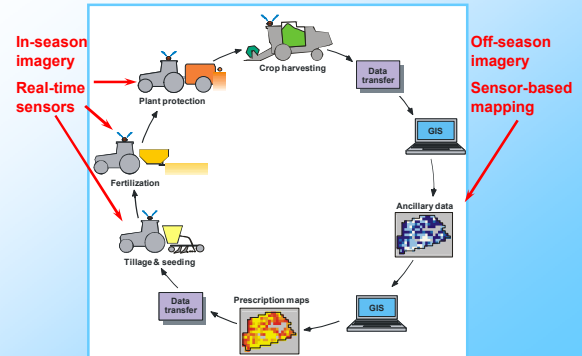
Decision Support System Upper-Level Control

On-Line Decision Support System



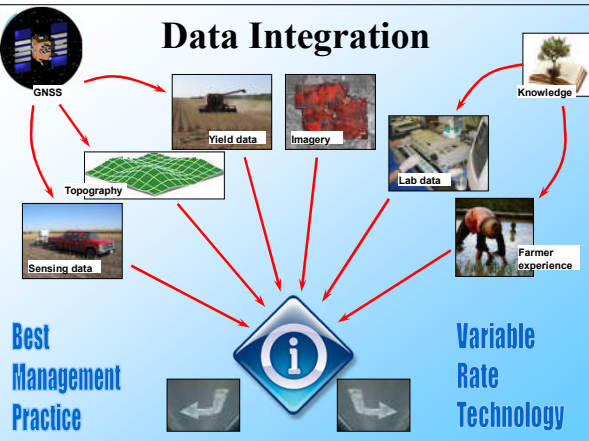
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Site-Specific Crop Management Lower-Level Control



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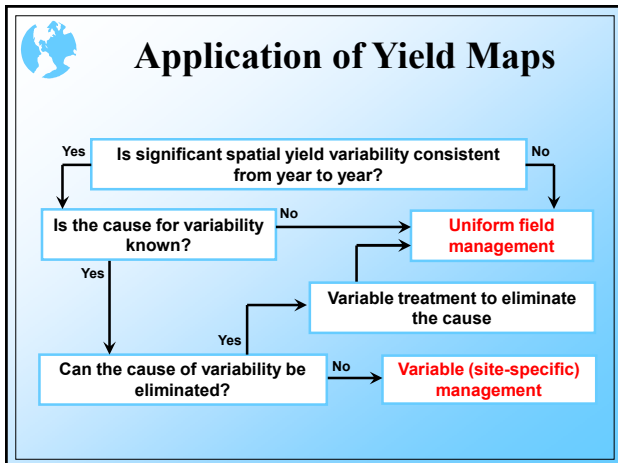
Data Integration



Best Management Practice

Variable Rate Technology

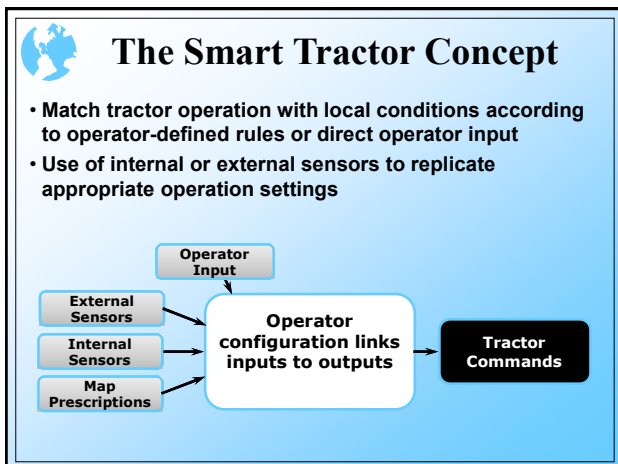
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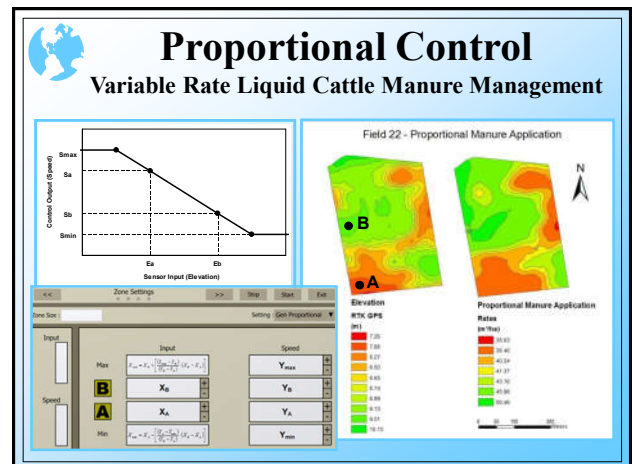
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- ### Site-Specific Crop Management
- Variable Tillage
 - Variable Application of Agricultural Inputs
 - Seeding and planting material
 - Dry chemicals (lime and granular fertilizer)
 - Liquid chemicals (liquid fertilizer and plant protection chemicals)
 - Gas fertilizer (anhydrous ammonia)
 - Variable Rate Irrigation

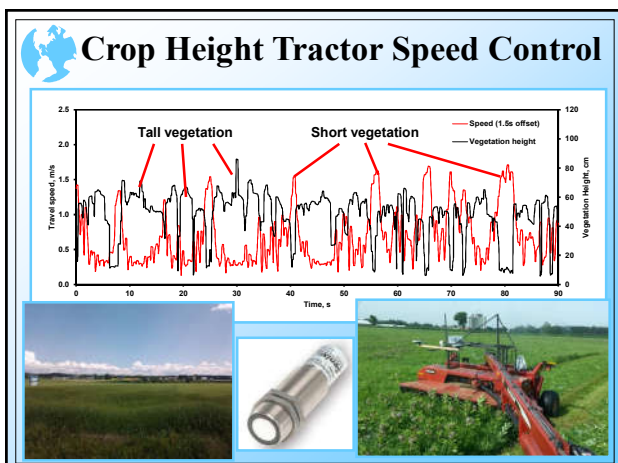
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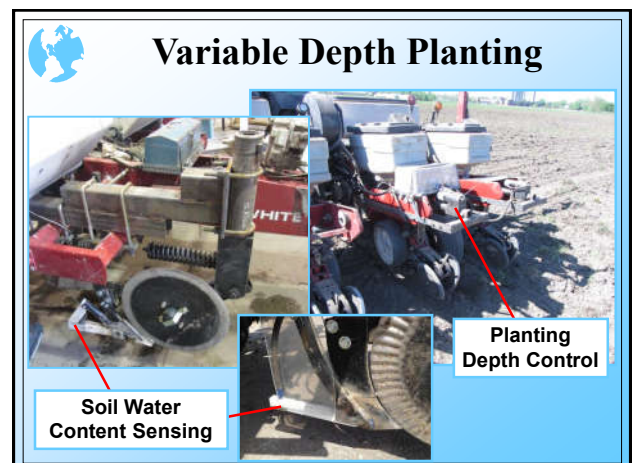
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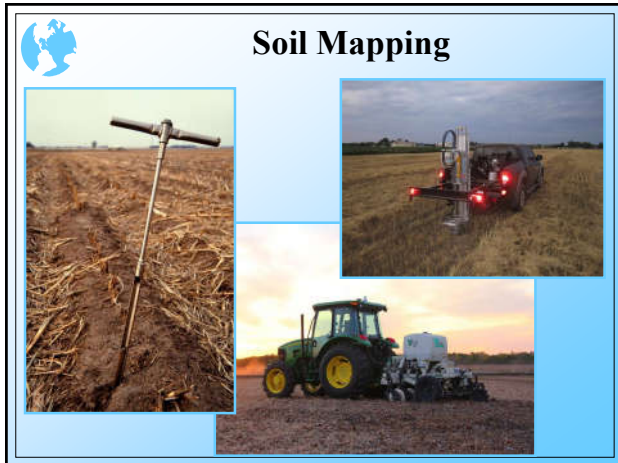
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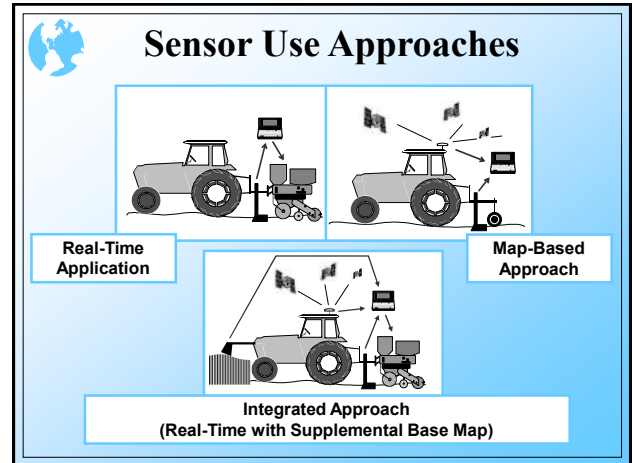
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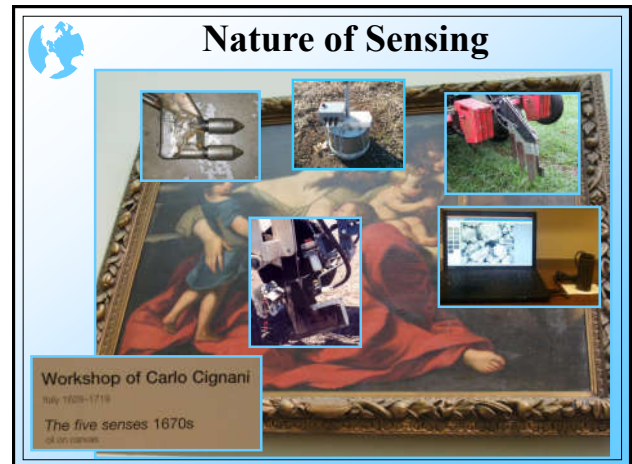
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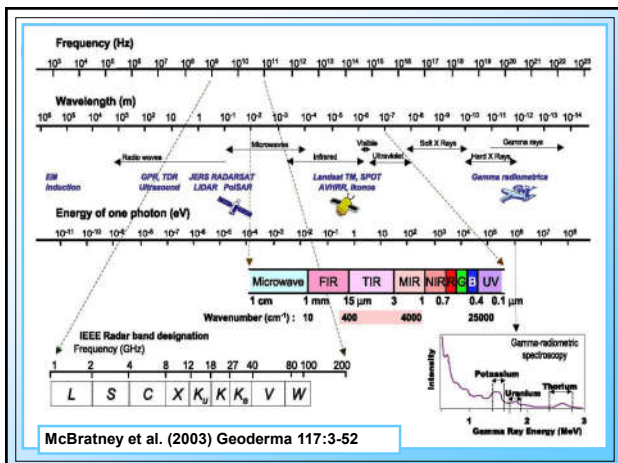
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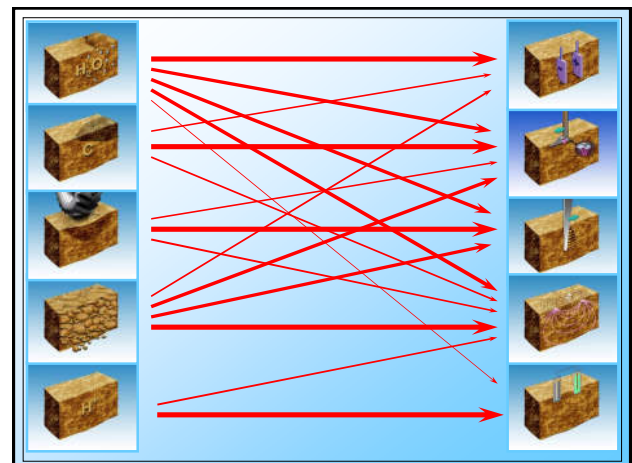
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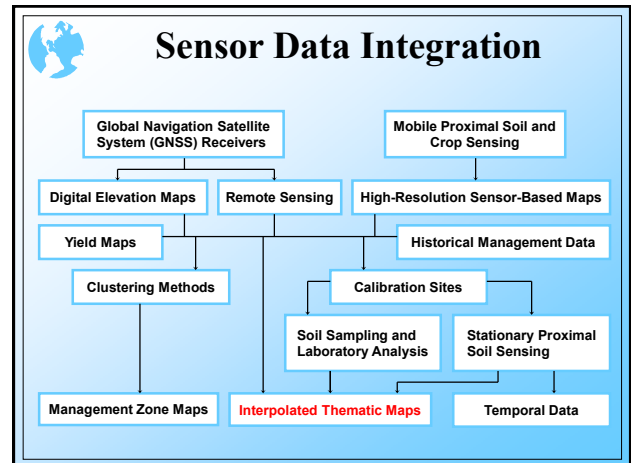


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Remote versus Proximal Sensing

Remote Sensing (> 2 m)	Proximal Sensing (< 2 m)
Satellite Aerial (high altitude) UAV (low altitude)	On-the-go (mobile) On-the-spot (stationary) Profiling (multi-depth)
	


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Site-Specific Tillage

- Continuous no-till
- Strip-till and controlled traffic
- Spot tillage of compacted areas
- Variable depth tillage in response to the depth of a hard pan



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Site-Specific Seed Management

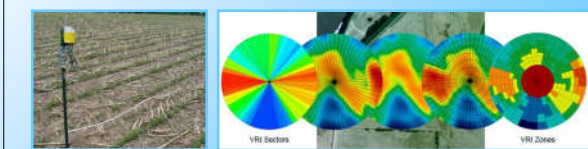
- Change rate to account for differences in water availability
- Change placement to optimize emergence
- Change the cultivar/hybrid in response to local environments



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Site-Specific Water Management

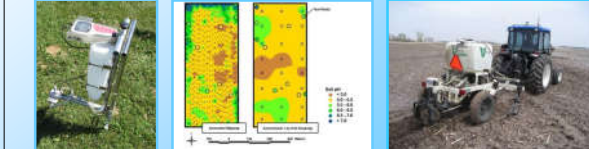
- Field landscaping and improved drainage
- Control water table if possible
- Optimized irrigation scheduling
- Variable rate irrigation



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Site-Specific Lime Management

- More lime is needed for low-pH soil
- No lime should be applied to neutral or alkaline soil
- It takes extra lime to raise pH in soils with high buffering capacity



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Site-Specific Nutrient Management

- Band placement of fertilizers (P and K)
- Relevance to past management (livestock)
- Historic crop removal (yield data)
- Mapping local needs (new sensors)
- Attention to micronutrients



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Site-Specific Nitrogen Management

- Apply when it is needed (use of inhibitors)
- Account for all possible credits (predictive)
 - Potential for N mineralization (soil organic matter)
 - Yield history (variable yield goal)
 - Soil nitrate-nitrogen
- In-season management (reactive)
 - Sensor-based fertilization of the crop under N stress
 - No waste of fertilizer with low expected crop intake



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Site-Specific Manure Management

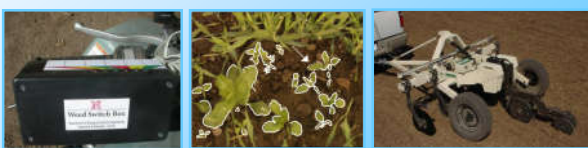
- Avoid environmentally risky areas
- Direct injection if possible
- Addressing soil health
- Accounting for nutrient variability
- Improved logistics



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Site-Specific Weed Management

- Apply herbicides in weeded areas only
- Change the product according to the weed species
- Change the rate according to soil carbon
- Weed control automation (mechanical/laser)



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Integrated Mapping Solutions

- Seeding rate
 - Topography, geophysics/radiometry, water content
- Liming rate
 - Soil pH, geophysics, optical reflectance
- Soil compaction
 - Mechanical impedance, water content, porosity
- Soil health
 - Microbial activity, optical reflectance, porosity, mechanical impedance
- Fertilization rate
 - Ion activity, geophysics/radiometry, vegetation status, removal rate, topography

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