SOIL HEALTH, DISEASE MANAGEMENT, AND POTATO CROPPING SYSTEMS

ROBERT LARKIN
Plant Pathologist

USDA-ARS, New England Plant, Soil, and Water Laboratory, University of Maine, Orono, ME

Soil Health

- Defined as the continued capacity of soil to function as a vital living system to sustain biological productivity, maintain environmental quality, and promote plant, animal and human health

- Emphasis on the importance of all the multiple functions of soil (biomass production, nutrient cycling, filtering and buffering, water storage/ availability, biological habitat, source of biodiversity)

- Encompasses physical, chemical, and biological attributes

- Building and maintaining soil health essential to agricultural sustainability and ecosystem function

Characteristics of Healthy Soils

- High organic matter
- High tilth (loose, friable structure)
- High water-holding capacity and drainage
- Adequate and accessible supply of nutrients
- Sufficient depth for root growth
- Large, diverse populations of beneficial soil organisms, microbial communities
- Low populations of plant pathogens and pests
- Resistant to degradation
- Resilient in ability to recover from stresses

Parameters Associated with Soil Health

- **Physical properties**
  - Texture
  - Bulk density
  - Aggregate stability
  - Water-holding capacity
  - Rooting depth
  - Infiltration
- **Chemical, nutritional properties**
  - Organic matter
  - C, N (Total, active, particulate)
  - P, K, Ca, Mg, Na, CEC
  - pH, EC
- **Biological properties**
  - Microbial biomass, activity
  - Microbial communities, indicator populations
  - Mineralizable N
  - Respiration

Management Practices Associated with Soil Health

- **Crop Rotations**
  - Crop type – disease-suppressive?
  - Length
  - Sequence
- **Cover crops and Green Manures**
- **Organic Amendments**
  - Compost, manure
  - Crop residues, mulches
- **Conservation Tillage**
  - Reduced, minimum, no-till

Soil Health and Disease Management

- Soilborne diseases are most severe when soil conditions are poor
  - Inadequate drainage, poor structure
  - Low organic matter, fertility
  - High soil compaction
  - Low microbial biomass and diversity

- Most practices that improve soil health will also reduce soilborne diseases
  - Improve conditions for crop growth, less disease
  - Increase microbial biomass, activity, & diversity
  - General disease suppression
  - Increase populations of antagonists

- Specific disease-suppressive practices and strategies for further disease reduction

Disease-suppressive crops

- *Brassica* and related crops

Canola, Rapeseed
Broccoli, Cabbage, Kale,
Cauliflower, Brussel Sprouts
Turnip, Radish
Mustards (black, brown,
yellow, white, oriental)

- Sudangrass (Sorghum/sudangrass hybrids)

Disease suppression

- Biofumigation – breakdown produces volatile toxic metabolites
- Changes in Soil Microbial Communities
- Most effective as green manures

Crop Management Strategy Study:

Potato variety: Russet Burbank

3-yr rotations (all entry points) – est. 2004; Presque Isle, ME

– continued through 2012

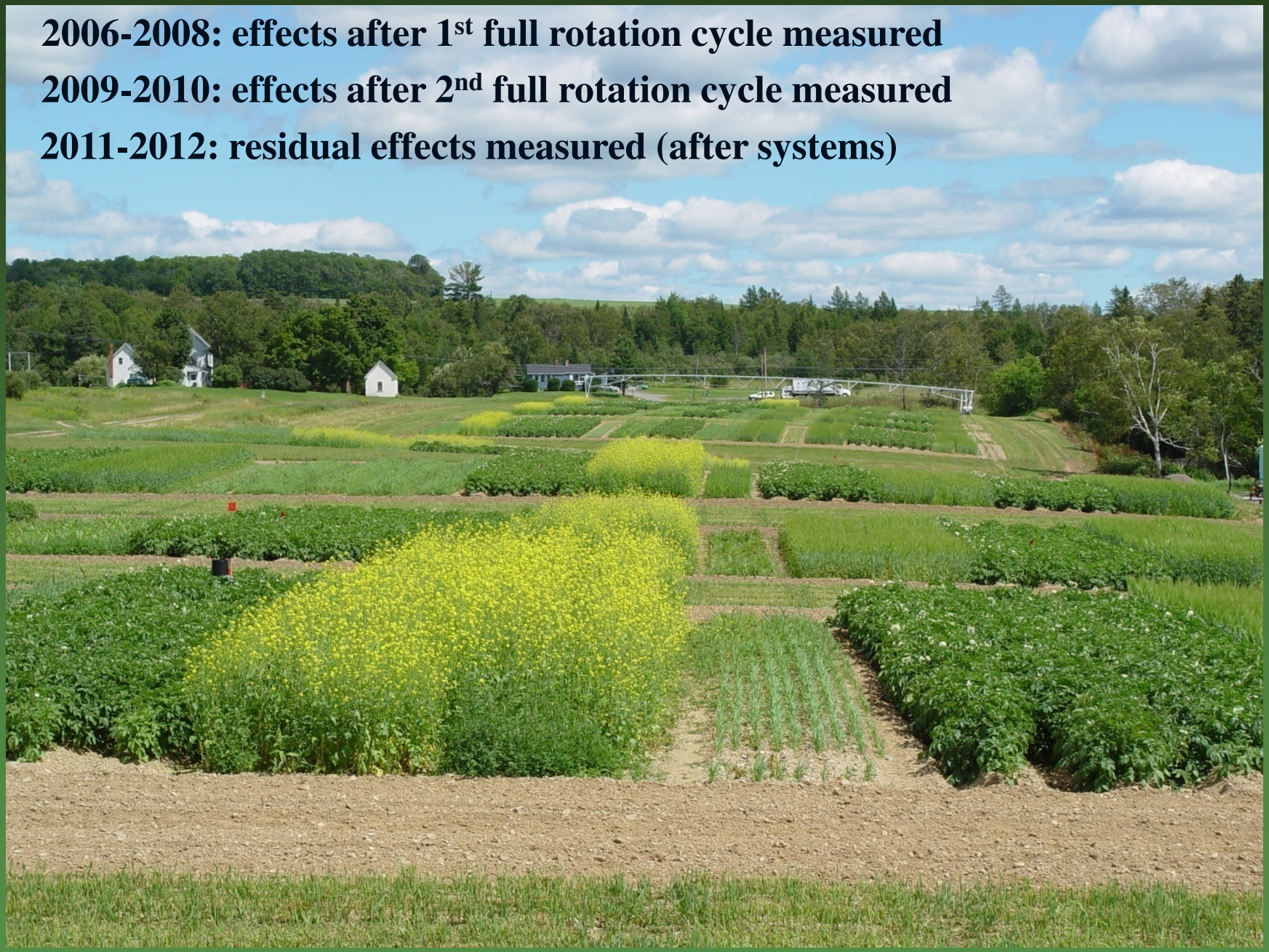
SQ -	**Status Quo (2-yr)**	**Barley (Clover) – Potato**
		Standard rotation
SC -	**Soil Conserving**	**Barley (Timothy) – Timothy**
		Limited tillage, straw mulch
SI -	**Soil Improving**	**Barley (Timothy) – Timothy**
		Plus Compost
DS -	**Disease-Suppressive**	**Mustard GM/rapeseed cover –**
		Sudangrass GM/rye cover
PP -	**Continuous Potato**	**Continuous Potato**

All treatments also implemented under both irrigated (IRR) and non-irrigated (NON) conditions, with irrigation as a split-block factor

2006-2008: effects after 1st full rotation cycle measured

2009-2010: effects after 2nd full rotation cycle measured

2011-2012: residual effects measured (after systems)



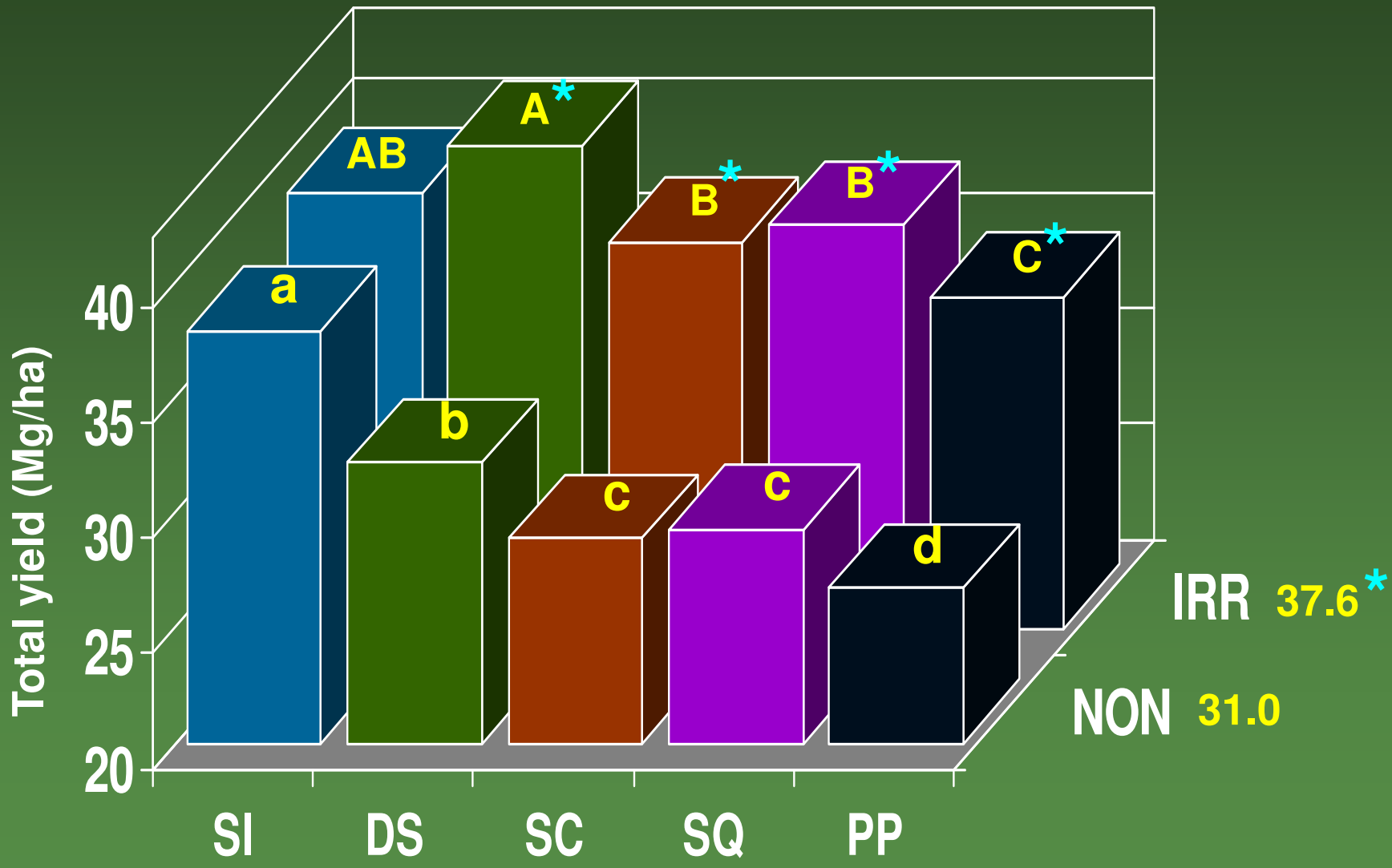
Effect of Crop Management Strategy on Selected Soil Physical Properties (after 2 full rotation cycles – 6 years)

Cropping System	Soil Moisture (%)	Water stable aggregates (%)	Bulk Density (g/cm^3)
SI	34.1 a	69.0 a	0.763 c
SC	28.1 b	69.7 a	0.856 b
DS	25.6 c	63.6 b	0.893 a
SQ	25.2 c	50.5 c	0.893 a
PP	22.9 d	45.7 d	0.904 a

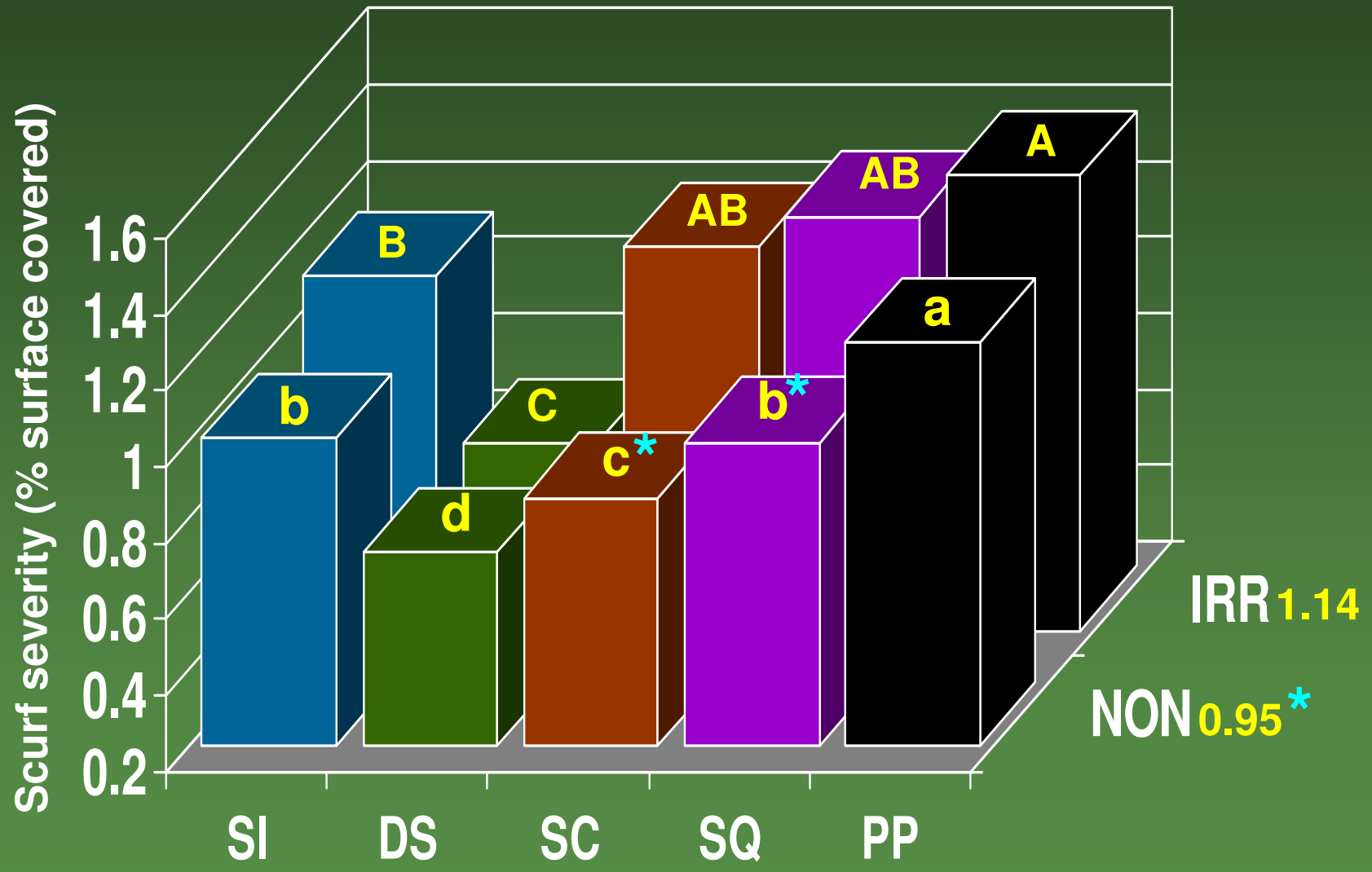
Effect of Management Strategy on Soil Chemical/Biological Properties

Cropping System	Total C (%)	Total N (%)	Active C (mg C /kg soil)	CEC (meq/100 g)	Microbial biomass C (mg C /kg soil)
SI	3.9 a	0.35 a	562 a	9.0 a	135.6 a
SC	2.3 bc	0.22 b	337 cd	5.3 b	99.0 b
DS	2.3 bc	0.22 b	346 bc	5.2 b	101.8 b
SQ	2.4 b	0.23 b	363 b	5.8 b	101.7 b
PP	2.2 c	0.21 b	318 d	5.9 b	84.7 c

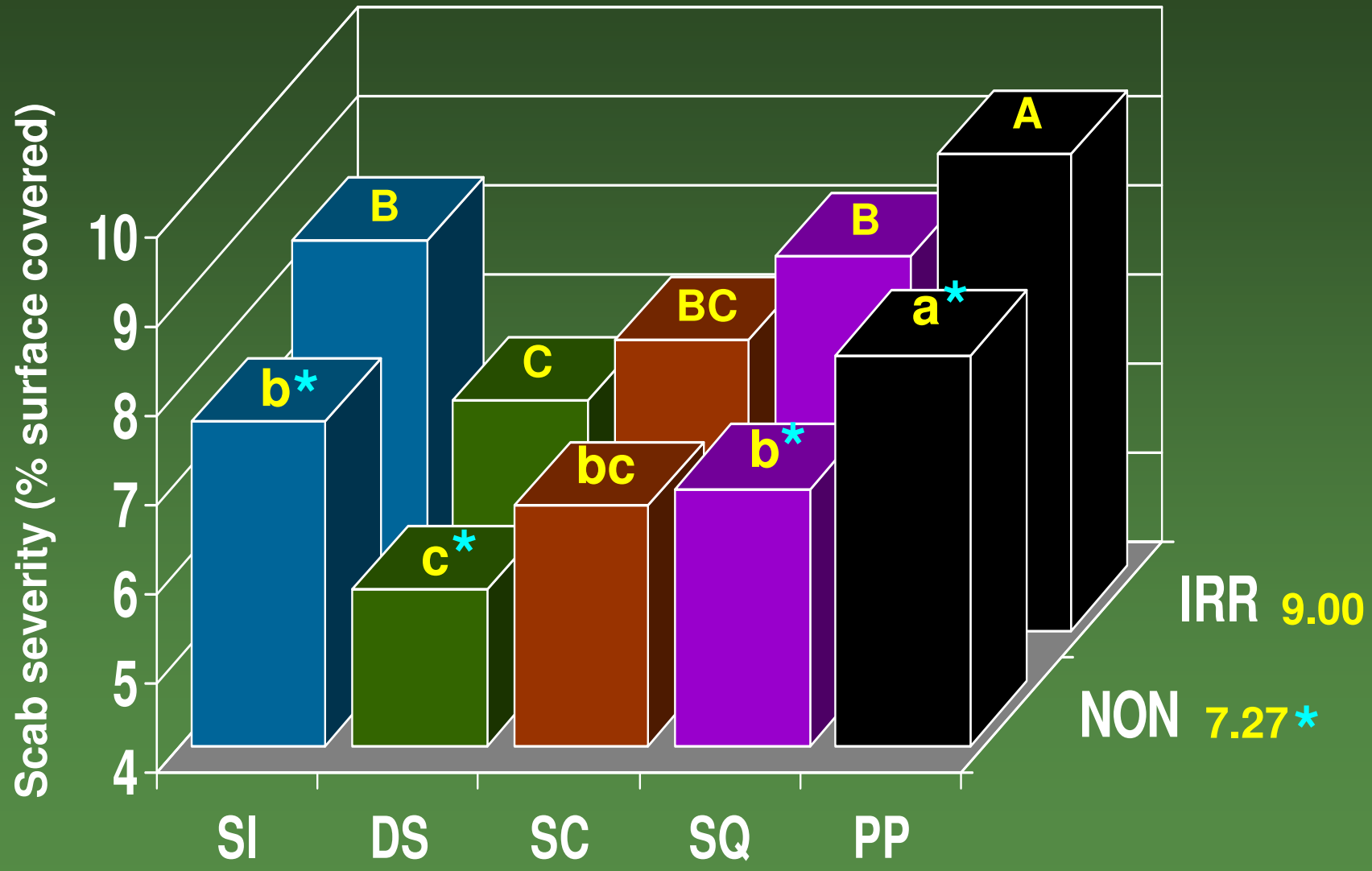
Effect of crop management strategy and irrigation on total tuber yield (after 2 full rotation cycles - 6 seasons)



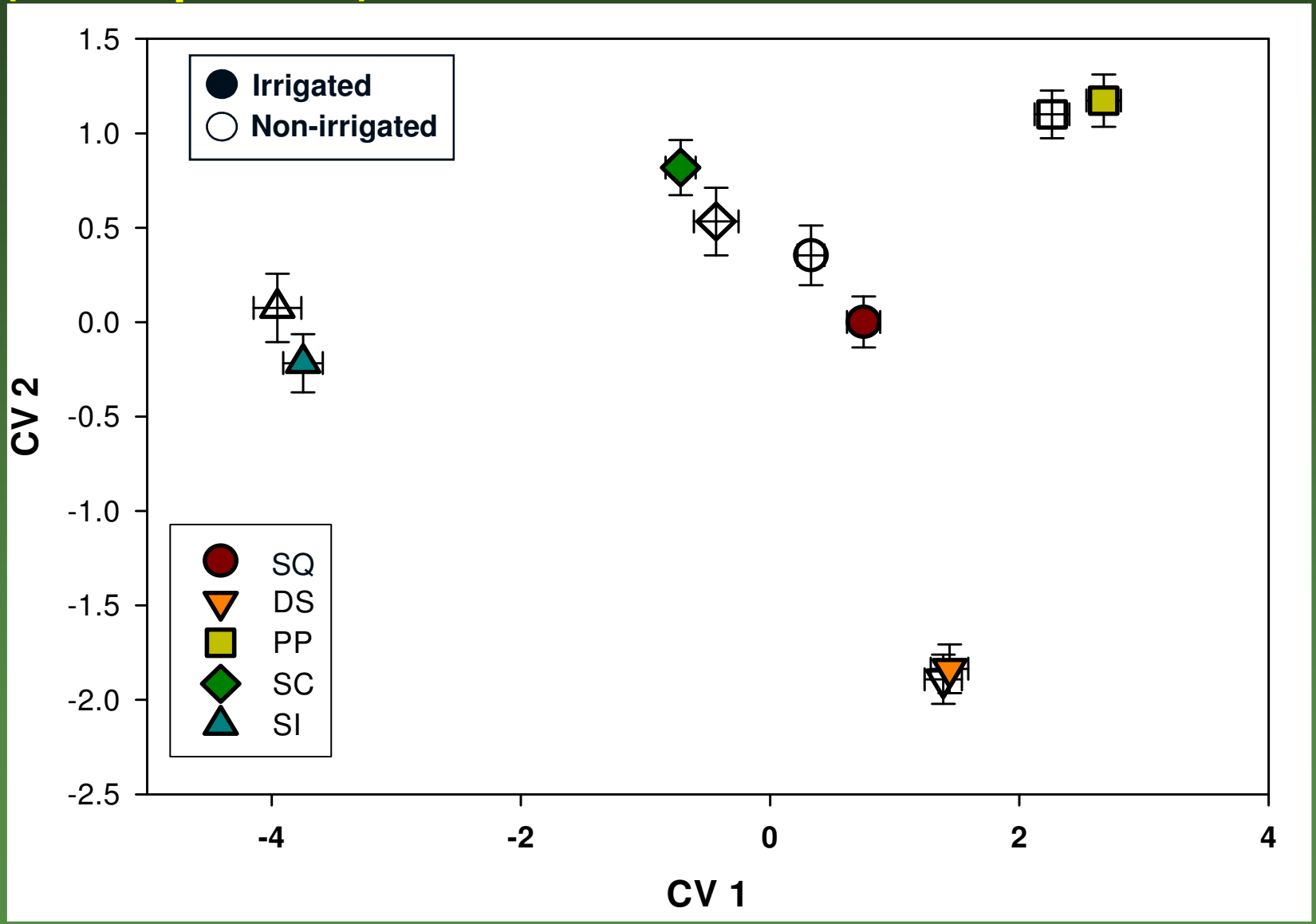
Effect of crop management strategy with and without irrigation on severity of black scurf



Effect of crop management strategy with and without irrigation on severity of common scab



Effect of crop management strategy with and without irrigation on soil microbial community characteristics (FAME profiles)



Disease-Suppressive Management Studies

Rotation Management Options: Study examined multiple rotation crops under different management practices.
2-yr rotations, each rotation examined over 2 field seasons, repeated
Presque Isle, 2009-2011

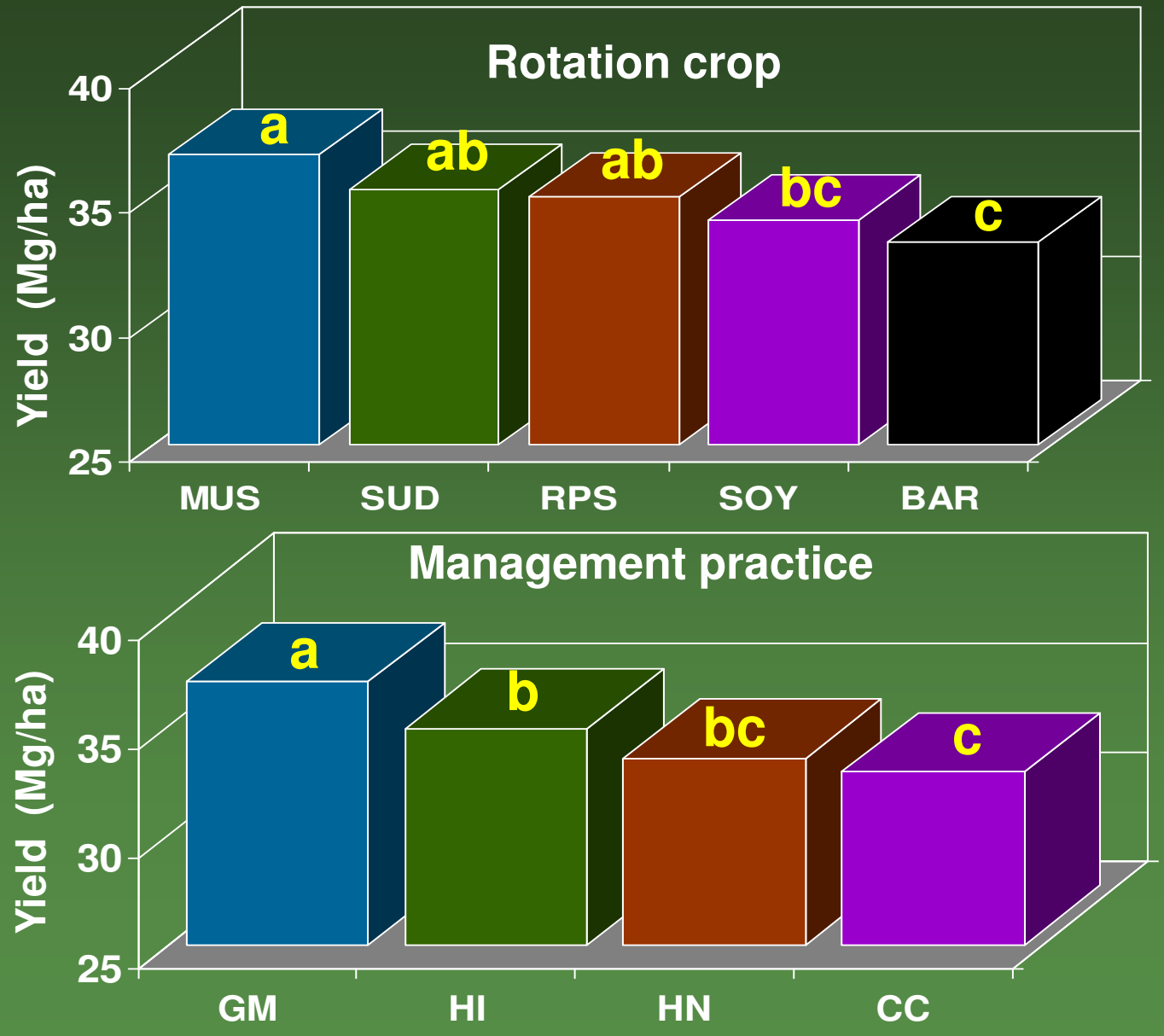
Crops:

- MUS - Mustard Blend
- SUD - Sudangrass
- RPS - Rapeseed
- SOY - Soybean (nonsuppressive control)
- BAR - Barley/clover (standard rotation control)

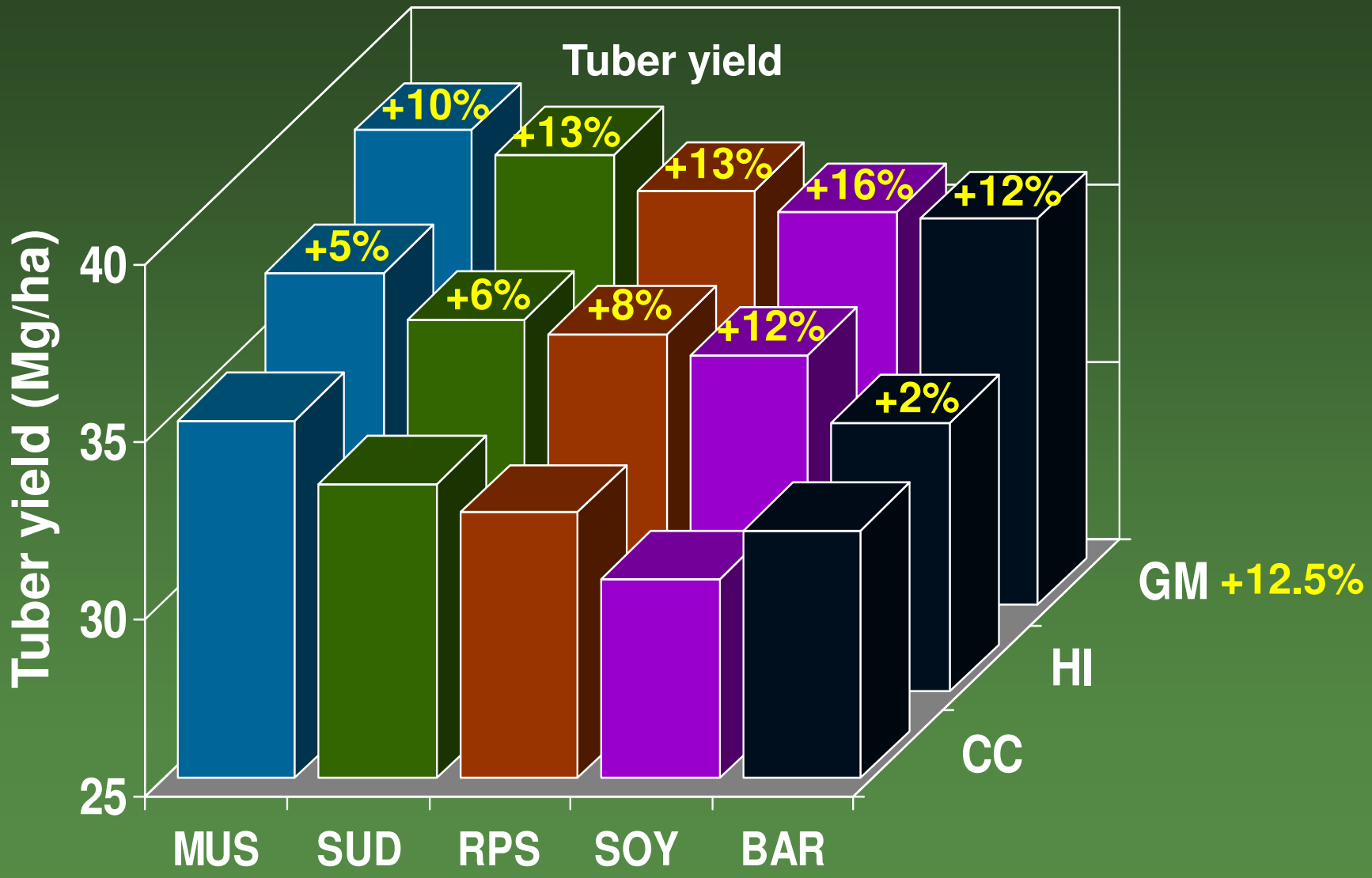
Management:

- GM - Green manure (incorporated green)
- CC - Cover crop (not incorporated)
- HI - Harvested (seed, oilseed), stubble incorporated
- HN - Harvested, stubble not incorporated

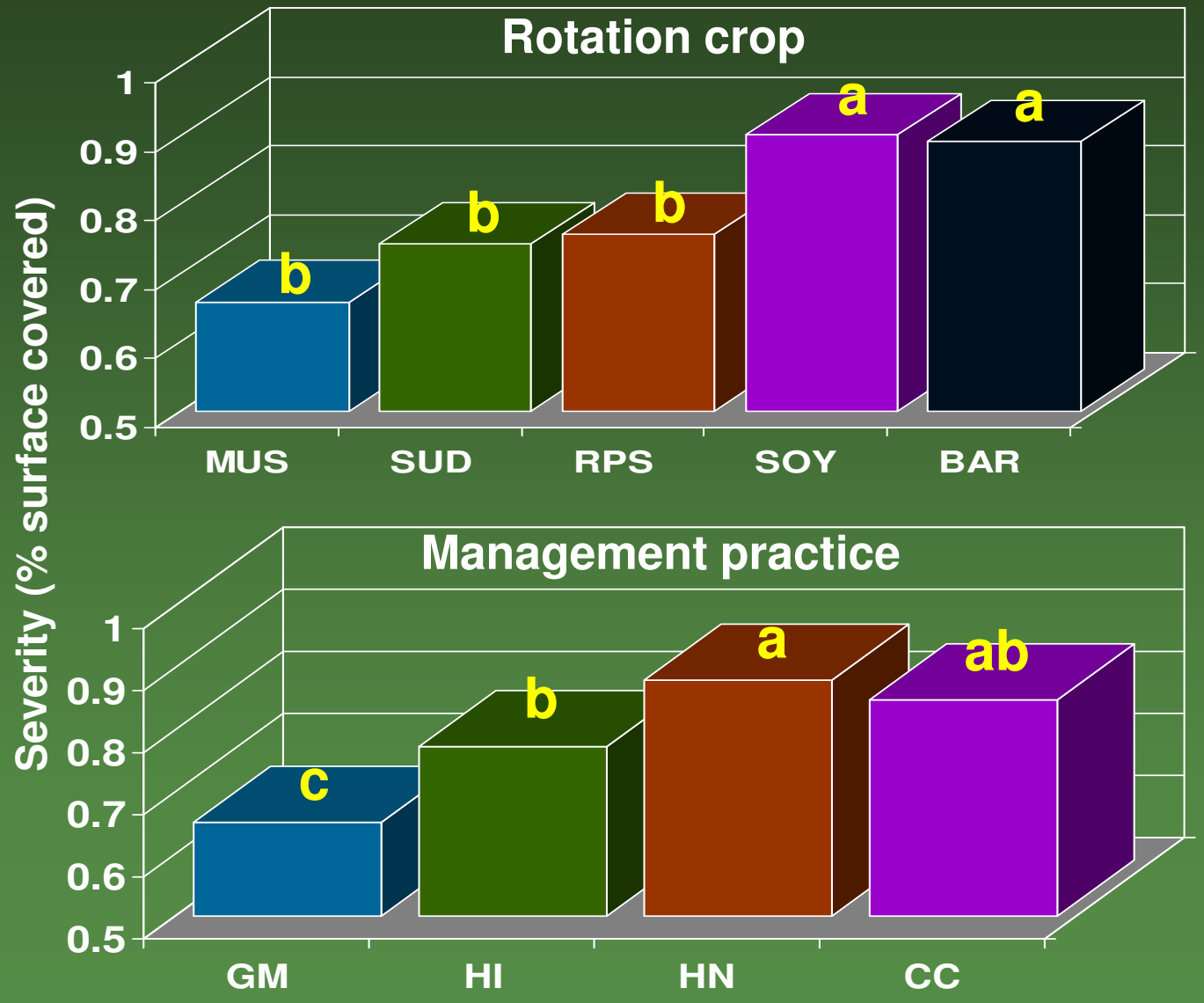
Effect of rotation crop and management practice on tuber yield (2-yr avg)



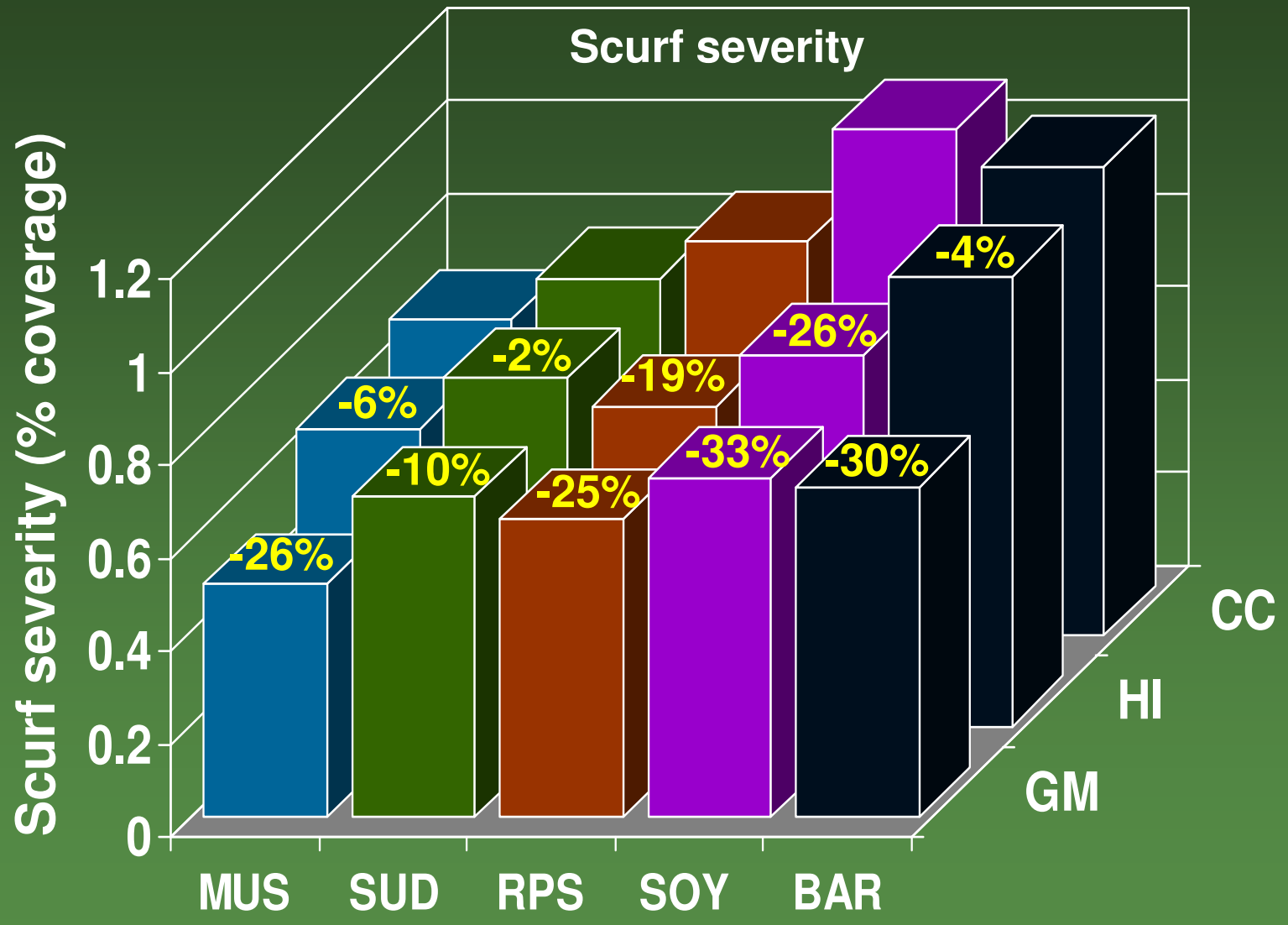
Effect of rotation crop and management practice on total tuber yield (2-yr avg)



Effect of rotation crop and management practice on black scurf severity (2-yr avg)



Effect of rotation crop and management practice on severity of black scurf (2-yr avg)



CONCLUSIONS

- Incorporating management practices that promote soil health into potato cropping systems can improve soil physical, chemical, and biological properties, resulting in improved nutrition, enhanced yield, and disease suppression
- All of the soil health-building practices, such as use of crop rotations, cover crops and green manures, organic amendments, and conservation tillage, contribute to building active, diverse, and potentially disease-suppressive microbial communities, and can provide the base of a sustainable disease management program.
- SI system, which included yearly compost amendments, had the greatest effects on soil health, including increases in total C and N, active C, microbial activity, water availability, CEC, and concentrations of P, K, Ca, and Mg, and reductions in bulk density, resulting in high yields, but only nominal disease reduction.

CONCLUSIONS

- DS system, which included disease-suppressive green manures and cover crops and increased crop diversity, provided more modest improvements in soil health parameters, but the greatest disease reduction, maintaining low disease levels throughout study period.

- Rotation crops grown as green manures were more effective than when grown as cover crops for effects on tuber yield and disease reduction

- Use of soil health management practices and disease-suppressive crops can substantially reduce soilborne disease problems, but cannot completely eliminate them, may take time to develop, and should be used in conjunction with other approaches to achieve sustainable disease management

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bob.larkin@ars.usda.gov