Dynamic Agricultural Systems and the Crop Sequence Calculator

An Introduction to the Concepts of Dynamic Agricultural Systems

USDA Agricultural Research Service

Northern Great Plains Research Laboratory

Mandan, ND

Dynamic Agriculture

The wise adapt themselves to circumstances, as water moulds itself to a pitcher.

Chinese Proverb

- **A dynamic cropping system is**
  - **an annual strategy of crop sequencing**
  - **that optimizes the outcome of**
    - **production,**
    - **economic, and**
    - **resource conservation goals**
  - **by using ecologically sound management principles.**

Dynamic Agriculture

- Implicit to this strategy is the need for producers to possess information necessary to respond to continual change.
- Changes in factors such as
  - weather, market conditions, government programs, and new information and technology
  - influence the feasibility and profitability of growing certain crops in a particular year.

Dynamic Agriculture

- By taking these factors into account when making annual cropping decisions, producers can create an adaptable cropping system;
- A system characterized by
  - greater responsiveness and
  - lower risk
  - than if a fixed cropping system were practiced.

Dynamic Agriculture

- Information requirements for dynamic cropping systems, however, pose significant challenges to agricultural research.

- New methodologies for evaluating crops and crop sequences are needed, along with the ability to translate scientific results into useable decision aids for producers.

Dynamic Agriculture

- With this information base, producers will have the tools needed to implement dynamic cropping systems that are
  - economically viable,
  - socially acceptable, and
  - environmentally sustainable.

Dynamic Agriculture

- Dynamic cropping systems are a subset of other possible systems within the framework of *dynamic agricultural systems*.

- The crop sequence calculator is designed to apply the concept of dynamic agricultural systems to the specific management of crop sequences and crop rotations.

Introduction

Farms and ranches of the Northern Great Plains contend with highly variable climate and soils resulting in a high-risk condition for producers to maintain environmental and economic sustainability.

- **Producers must account for escalating production costs and increasing pressure to maintain a healthy environment.**
- **The complexity of issues affecting producers requires innovative approaches for developing environmentally and economically sustainable management systems.**

Our Mission

- The mission of the Northern Great Plains Research Laboratory, Mandan, ND is to
  - develop environmentally and
  - economically
    - » sustainable and
    - » integrated
  - crop and livestock management systems
  - for conservation and efficient use of natural resources.

Our Approach

A multi-disciplinary team conducts research to develop long-term, diverse cropping systems using

- alternative and conventional crops,
- tillage practices,
- crop sequences and rotations,
- residue management, and
- soil fertility

to improve crop production, precipitation use, weed and disease control, and reduce pesticide use.

Our Approach

- The team determines the effects of crops, cropping systems, tillage practices, residue, soil fertility, and pest management on soil water use and storage, and indicators of soil quality.
- A multi-phased program to develop long-term diverse cropping systems is being conducted with early- and late-season grass and broadleaf crops.
- Plant diseases, weed ecology, root growth, and indicators of soil quality are accessed for various crop sequences and crop residues.

Our Approach

- Key plant and soil factors are used to develop guidelines for long-term diversified crop production systems and provide producers with a flexible method for developing their own cropping systems.
- Improved cropping systems will provide producers with economic benefits from knowledge of which crops and crop sequences will result in the greatest production while allowing for reduced input costs.
- In addition to reducing agricultural chemicals, environmental benefits of improved cropping systems are realized through enhancement of soil quality, decreased soil erosion, more efficient use of soil water, and increased storage of soil carbon.

Our Approach

- *Dynamic cropping systems* will create a more sustainable agriculture in the Northern Great Plains by increasing producer income, reducing reliance on inputs, and enhancing the environment by reducing soil erosion and improving soil quality attributes.

Conceptual Basis

- A *dynamic cropping system* is a form of crop production that relies on an annual strategy of growing crops to
  - optimize the outcome of production, economic, and resource conservation goals, and
  - allow producers to use crops and crop sequences that result in the greatest production with minimum input costs
- for the purpose of developing agricultural systems that are
  - economically viable,
  - socially acceptable, and
  - environmentally sustainable.

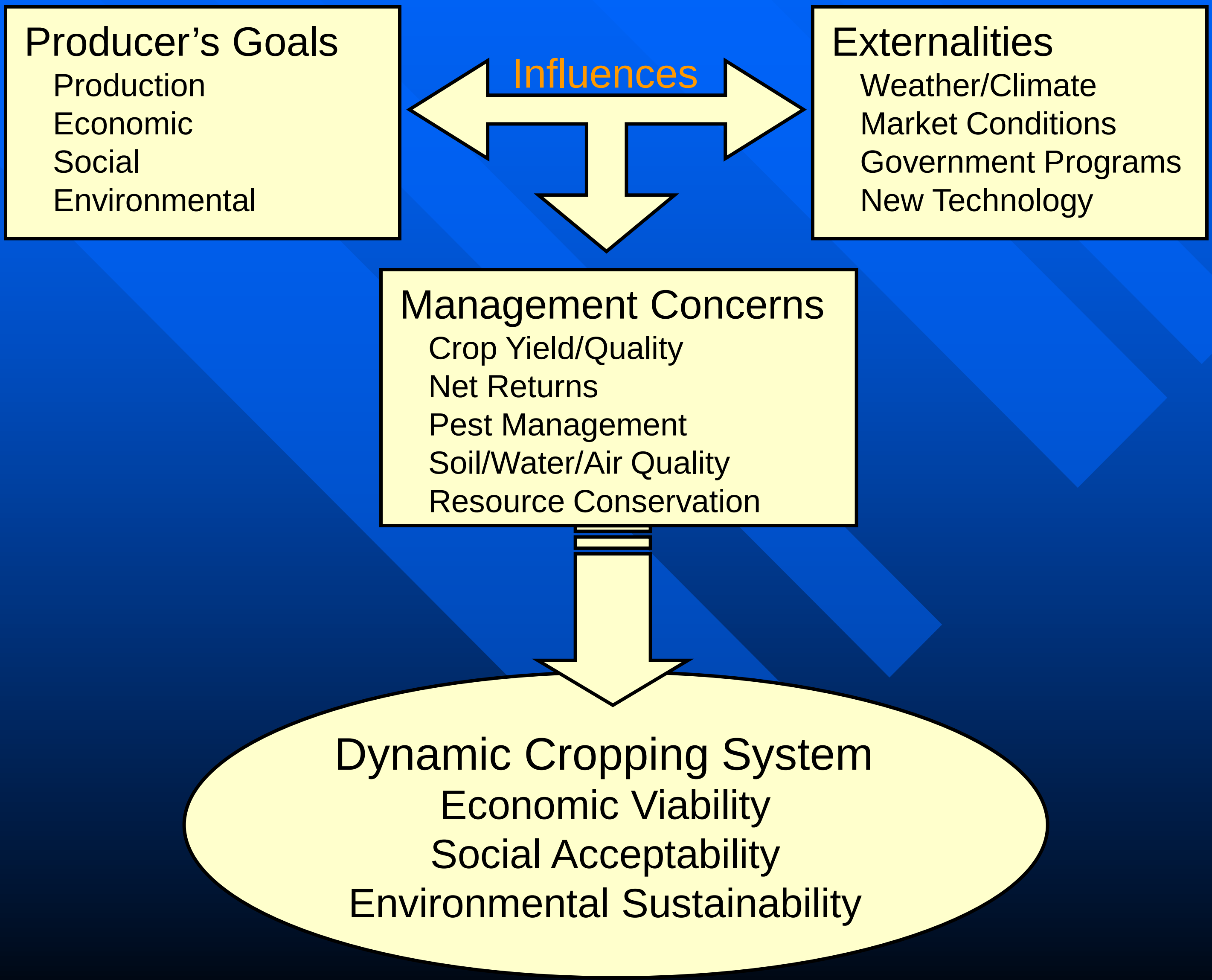
Conceptual Basis

- Emphasis is on long-term diversified crop production systems.
- Environmental benefits of improved cropping systems include
  - reducing the use and movement of agricultural chemicals,
  - enhancing soil quality,
  - decreasing soil erosion,
  - increasing efficiency of soil water use, and
  - increasing storage of soil carbon.

Conceptual Basis

- By taking these factors into account when making annual cropping decisions, producers can create an adaptable cropping system characterized by
  - greater responsiveness and
  - lower risk than available using a fixed cropping system.
- Incorporation of concepts from the remaining presentations in this series will provide the tools needed to implement *dynamic cropping systems*.

Important Considerations



Keys To Dynamic Agriculture

Diversity: Increasing the variety of the products produced within an enterprise, decreases economic risk.

Reduced Input Cost: Any decrease of input costs increases net returns.

Adaptability: Producers must be ready to take advantage of new opportunities and enhanced production practices.

Multiple Enterprises: Producers are positioned more favorably if several enterprises are exploited, e.g. grain crops plus livestock.

Environmental Awareness: The future of an agricultural enterprise rests in the ability of the manager to conserve natural resources.

Information Awareness: The producer who accurately evaluates incoming information and applies the best of that information will be the most competitive.

Diversity in Rotations:
Multiple Benefits

- Increased Yield
- Pest Management
- Economic Stability
- Efficient use of Resources

Diversity Improves Water-Use Efficiency of Winter Wheat

Akron, CO

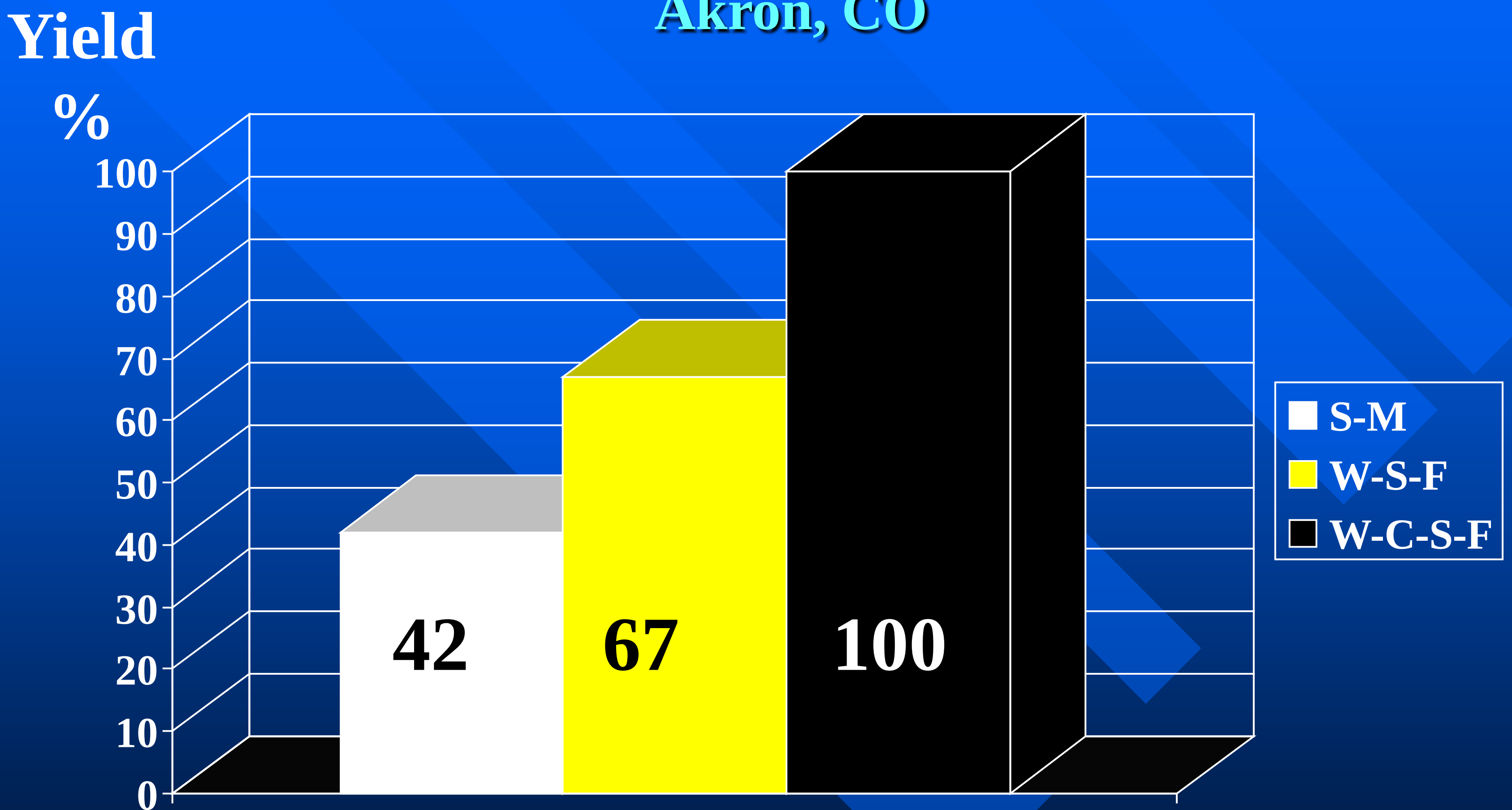
	W-C-M-F	W-C-S-F
Yield (bu)	50	47
Yield (lbs)	3000	2820
Water Use (in)	16	13
WUE (lb/ac/in)	**185**	**220**

WUE = Water-use efficiency

W = winter wheat, C = corn, M = proso millet, S = Sunflower

Frequency of Cropping and Sunflower Yield

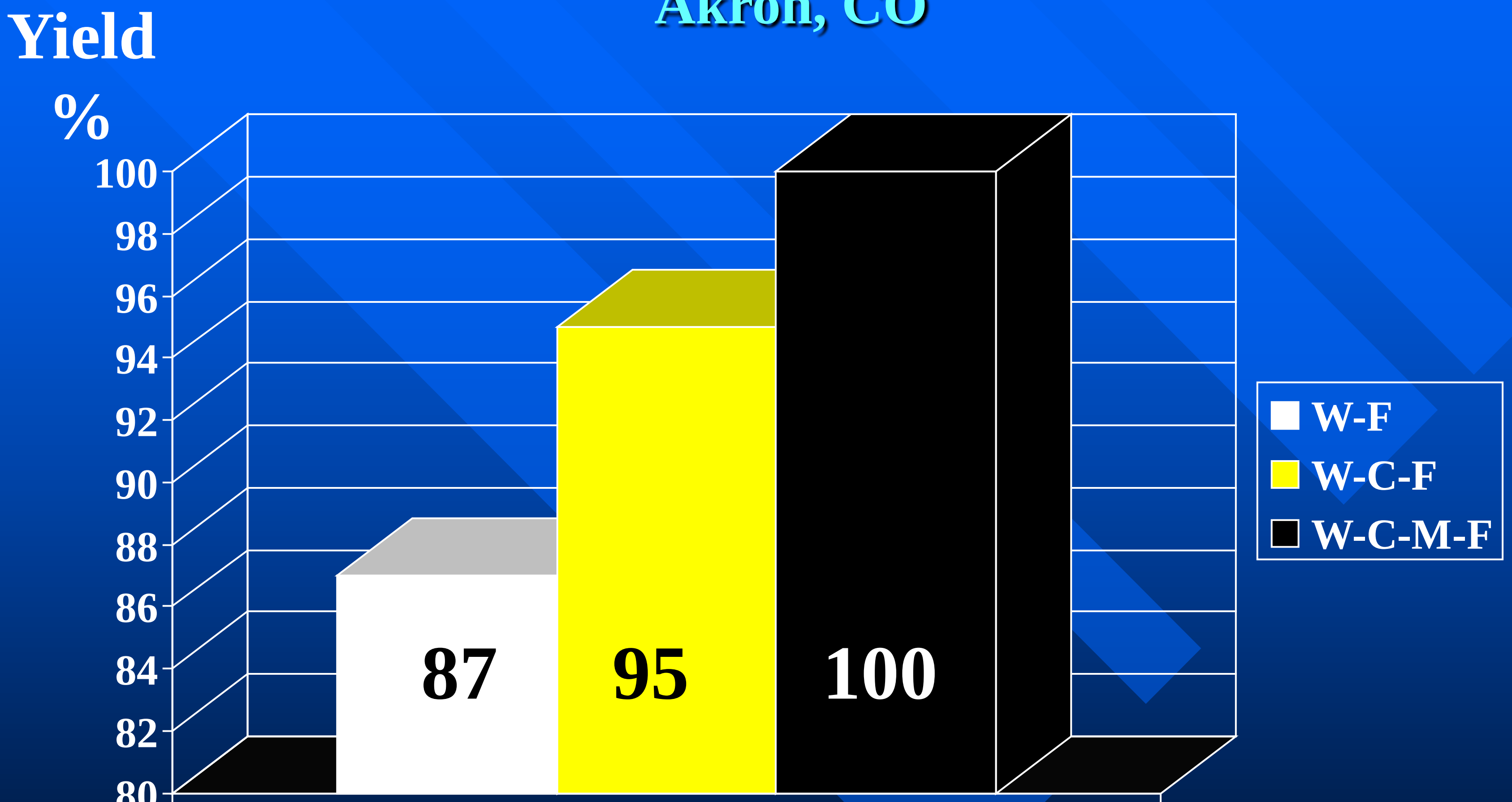
Akron, CO



S = Sunflower, M = Proso millet, W = Winter wheat, C = Corn, F = Fallow

Frequency of Cropping and Winter Wheat Yield

Akron, CO



W = Winter wheat, F = Fallow, M = Proso millet, C = Corn

Crop Sequence Calculator: Data Generation

- Crop Sequence Project is being conducted at

  USDA-Agricultural Research Service
  Northern Great Plains Research Laboratory
  Mandan, ND

www.mandan.ars.usda.gov

Crop Sequence Calculator: Data Generation

- The Crop Sequence Calculator is based on data collected by scientists at the Northern Great Plains Research Laboratory.
- Following is a description of the method for collecting data for the Calculator.

Crop Sequence Calculator: Data Generation

- A crop by crop residue matrix was formed so that ten crops
  - Barley *(Hordeum vulgare)*, canola *(Brassica napus)*, crambe *(Crambe abyssinica)*, dry pea *(Pisum sativum)*, dry bean *(Phaseolus vulgaris)*, flax *(Linum usitatissimum)*, safflower *(Carthamus tinctorius)*, soybean *(Glycine max)*, sunflower *(Helianthus annuus)*, and spring wheat *(Triticum aestivum)*
- were seeded into the crop residue of the same ten crops.

Crop Sequence Calculator: Data Generation

- During the first year, ten crops were no-till seeded
  - in strips
  - with a no-till drill
  - into a uniform cereal residue.
- During the second year, the same crops were
  - no-till seeded
  - perpendicular over the residue of the previous year’s crop.

Crop Sequence Calculator: Data Generation

- Crop by crop residue matrix in the field for two years.

Crop by Crop Residue Matrix, 1 Replicate, 100 Plots

1	2	3	4	5	6	7	8	9	10	1
11	12	13	14	15	16	17	18	19	20	2
21	22	23	24	25	26	27	28	29	30	5
31	32	33	34	35	36	37	38	39	40	9
41	42	43	44	45	46	47	48	49	50	7
51	52	53	54	55	56	57	58	59	60	10
61	62	63	64	65	66	67	68	69	70	6
71	72	73	74	75	76	77	78	79	80	3
81	82	83	84	85	86	87	88	89	90	4
91	92	93	94	95	96	97	98	99	100	8
5	2	7	1	8	4	6	9	3	10	

1st year, ten crops seeded in strips

2nd year, ten crops seeded perpendicular over crop residue

The Crop Sequence Calculator: Crop Varieties

Crop	Variety	Ideal Seeding Date	Test Weight (lb/bu)	Viable Seeds/Acre
Canola	Dynamite	Late April to mid-May	50	1 Million
Crambe	Meyer	Late April to early May	25	800,000
Dry Bean	T-39 (1999) Black Shadow (1998, 2000)	After all possible chance of frost to first week in June	60	90,000
Dry Pea	Profi	Early April to mid-May	60	350,000
Flax	Omega	Late April to mid-May	56	4 Million
Safflower	Montola 2000	Late April to early May	38	200,000
Soybean	Jim	Late May to first week in June	60	200,000
Sunflower	Cenex 803	Mid-May to early June	32	28,000
Spring Wheat	Amidon	Late March to mid-May	60	1.3 Million
Barley	Stander	Late March to mid-May	48	1.3 Million

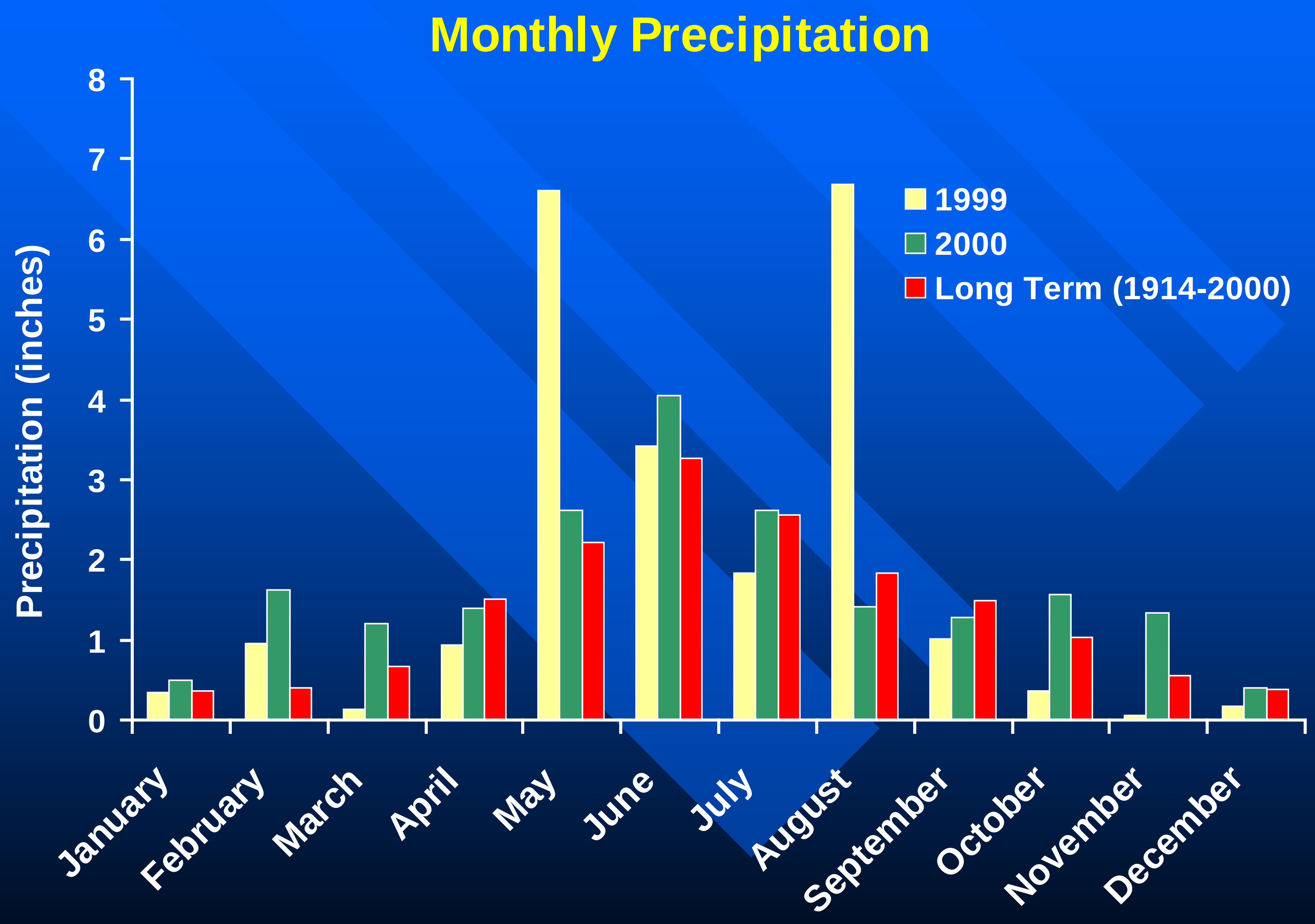
Fertilizer Rates
60# Nitrogen (Ammonium Nitrate)/Acre
10# Phosphorus (0-44-0)/Acre

Seeding
All crops were no-till seeded.
All N fertilizer was banded at seeding.
All P was placed with the seed at seeding.

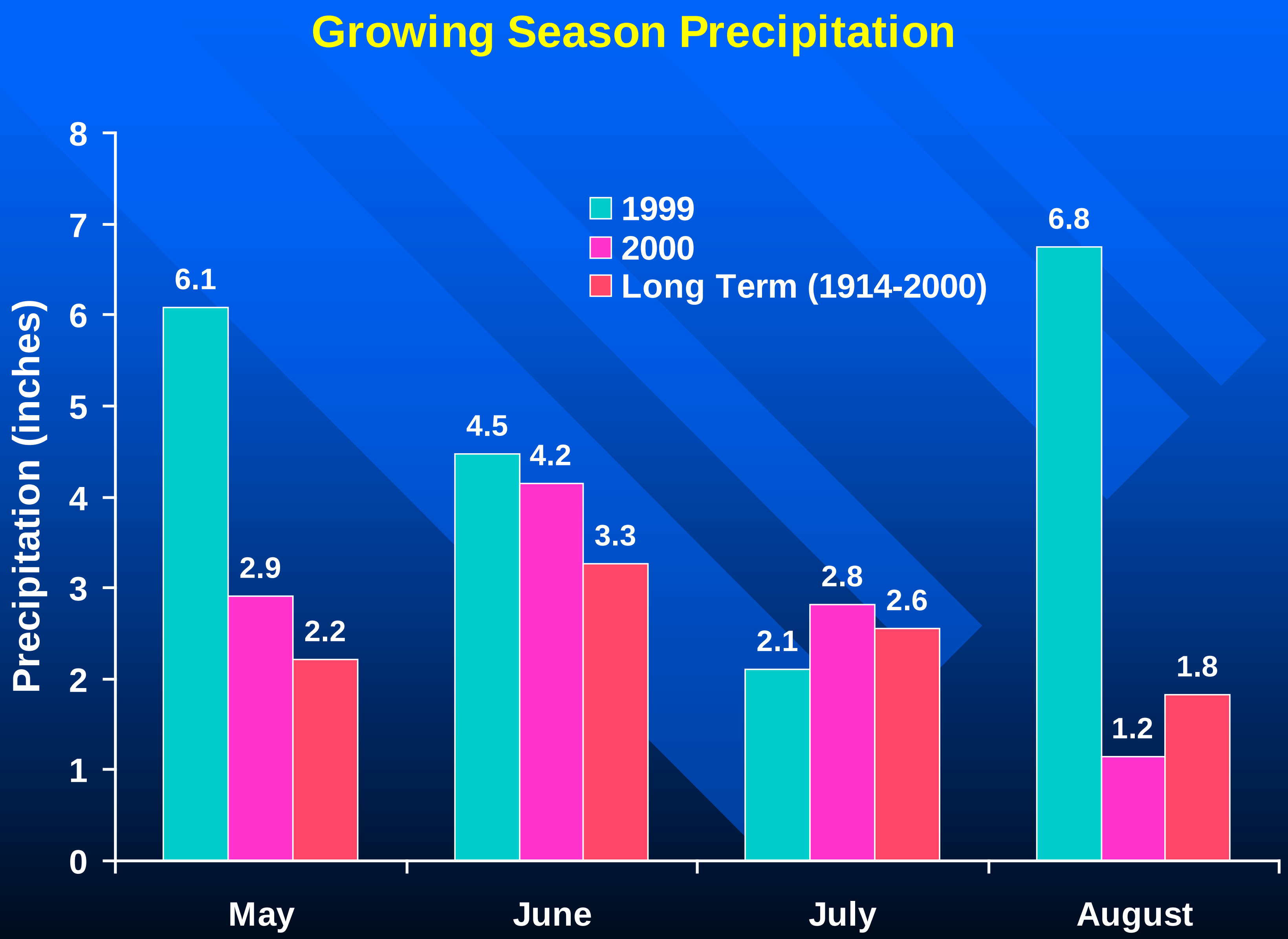
Crop Sequence Calculator: Landscape and Soil Type

- The experiment was conducted on
  - a nearly level (0-3% slope)
  - Wilton silt loam.
- The Wilton series consists of
  - very deep,
  - well drained soils
  - that formed in a silty loess mantle overlying glacial till.
- Taxonomy: fine-silty, mixed, superactive, frigid Pachic Haplustoll.

Crop Sequence Calculator



Crop Sequence Calculator



Crop Sequence Calculator

- Information in this program is
  - Based on data collected through 2001 and
  - is part of an on-going diverse cropping systems project.
- As this project evolves, additional principles and guidelines will be presented in new versions of the CSC.
- **No material in the CSC may be copied or distributed in part or whole without permission of the research scientists involved.**