Dynamic Cropping Systems and the Crop Sequence Calculator

Context, Concepts, Design, and Application

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Context

The sustainability of agriculture faces significant challenges in the 21st century. These challenges include:

- Population growth
- Dependence on fossil fuels
- Global climate change
- Globalization

From Hanson et al. (2007)

Context

Adapting to future challenges will require the development of new and innovative production systems that…

…are highly productive,
effectively utilize renewable resources, and
minimize damage to the environment…

…all in a context of continuous socioeconomic and environmental flux.

From Hanson et al. (2007)

Context

Consequently, future management strategies to increase agricultural sustainability must be dynamic in order to provide producers with multiple options for adapting to changing conditions.

From Hanson et al. (2007)

Dynamic Cropping Systems

A dynamic cropping system is an annual strategy of crop sequencing that optimizes the outcome of…

- ✓ **production,**
- ✓ **economic, and**
- ✓ **environmental goals**

…by using ecologically sound management principles.

From Tanaka et al. (2002)

Concept

- Implicit to a dynamic approach to crop sequencing 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.

Concept

By taking these factors into account when making annual crop sequencing decisions, producers can create an adaptable cropping system; a system characterized by…

…**greater responsiveness and lower risk**…

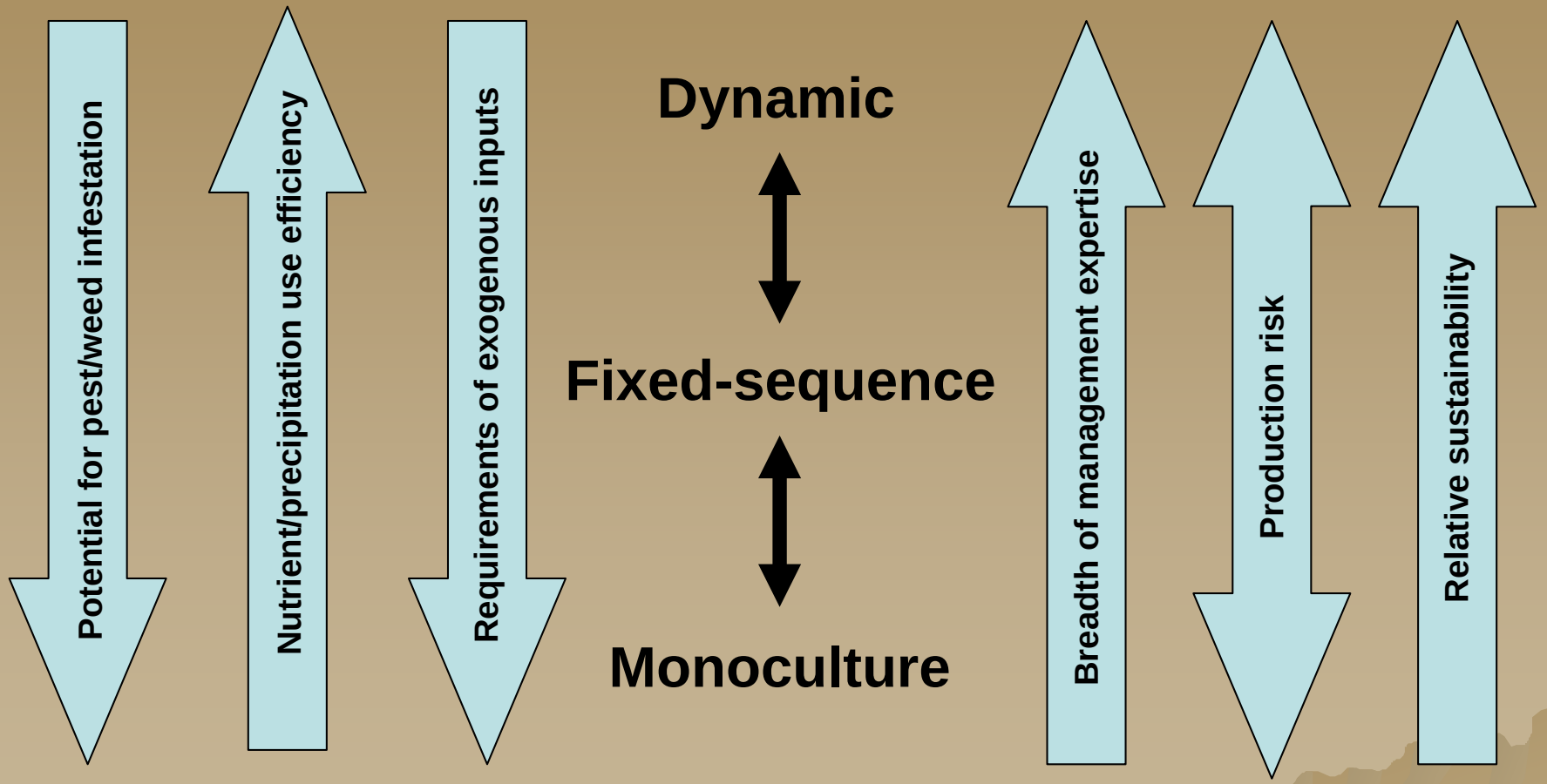
…than if a fixed-sequence cropping approach were used.

- - - - - - - - - Crop sequencing approach - - - - - - - - -

Attribute	Monoculture	Fixed-sequence	Dynamic
Crop portfolio	Single crop	Multiple crops; number dependent on regionally adapted species, economics, farmer knowledge, infrastructure	Multiple crops; number dependent on regionally adapted species, economics, farmer knowledge, infrastructure
Crop diversity	N/A	Diversity dependent upon length of fixed sequence	Diversity inherently high due to annual variation in growing conditions and marketing opportunities, as well as changes in producer goals
Crop sequencing flexibility	N/A	None, although fixed-sequence cropping systems that incorporate opportunity crops increase flexibility	High. All crops, in essence, are opportunity crops
Biological and ecological knowledge	Basic knowledge of agronomy	Some knowledge of crop interactions is necessary	Extended knowledge of complex, multi-year crop and crop by environment interactions
Management complexity	Generally low, though variable depending on crop type	Complexity variable depending on length of fixed sequence and diversity of crops grown	Complexity inherently high due to annual variation in growing conditions, markets, and producer goals

From Hanson et al. (2007)

Concept



From Hanson et al. (2007)

Concept

- Information requirements for dynamic cropping systems pose significant challenges to agricultural research.
- Novel methodologies for evaluating crops and crop sequences are needed, along with the capacity to effectively translate results into useable decision aids for producers.

Design

- At the USDA-ARS Northern Great Plains Research Laboratory, a crop by crop residue matrix was used to evaluate influences of crop sequence on agronomic and environmental attributes.
- 10 crops were evaluated in a matrix.

Design

- In the first year, 10 crops were…
  - seeded in strips
  - with a no-till drill
  - in a uniform cereal residue.
- In the second year, the same crops were…
  - no-till seeded
  - perpendicular over the residue of the previous year's crop.

Crop by Crop Residue Matrix

- ✓ Each matrix was present in the field for two years and replicated four times.
- ✓ Plots were monitored for two years following the matrix to quantify residual crop sequence effects.

Crop x Crop Residue Matrix

One 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

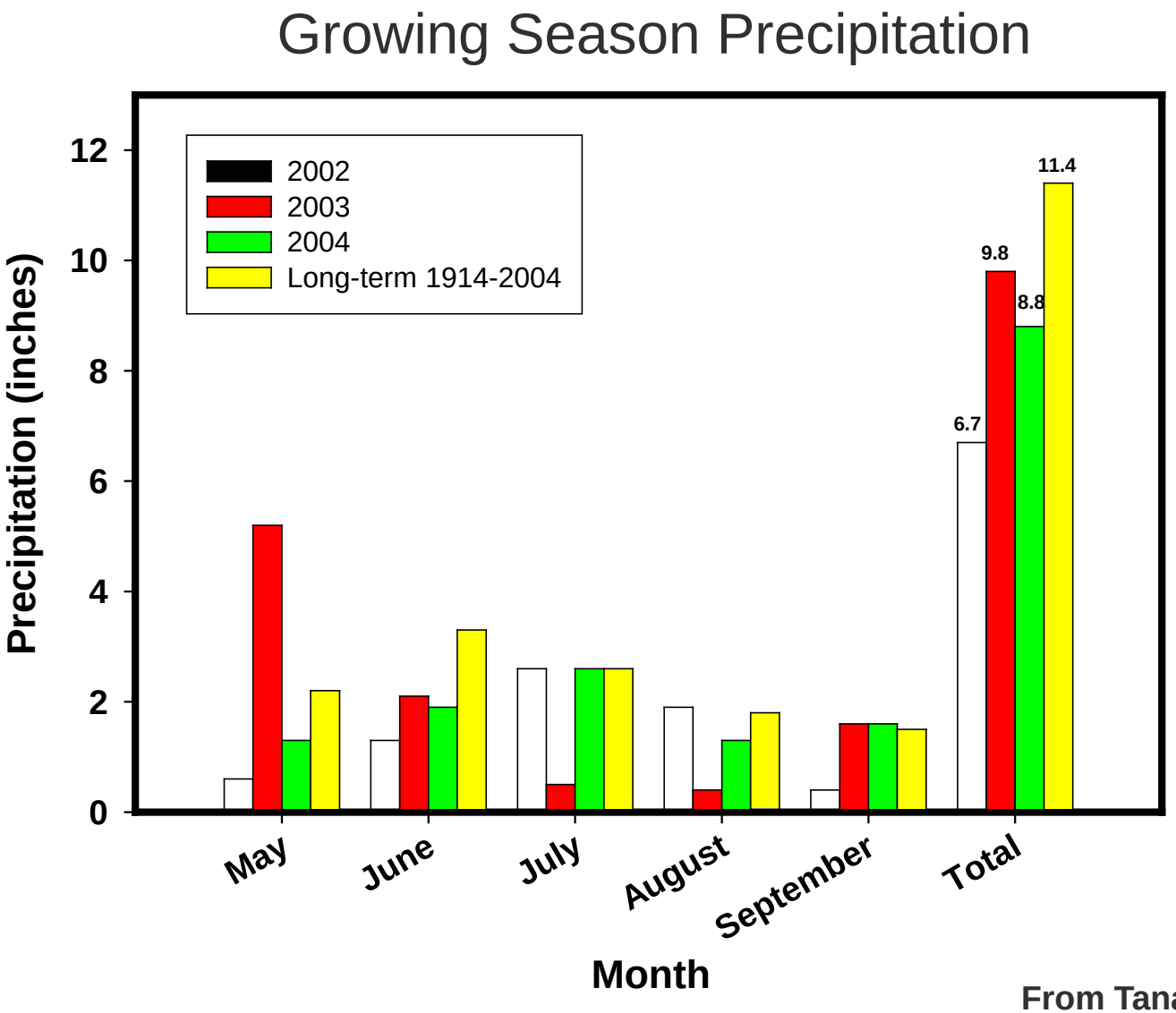
Crops Evaluated

- The following 10 crops were evaluated using the crop by crop residue matrix:
  - ✓ **Buckwheat (*Fagopyrum esculentum* Moench)**
  - ✓ **Canola (*Brassica napus* L.)**
  - ✓ **Chickpea (*Cicer arietinum* L.)**
  - ✓ **Corn (*Zea mays* L.)**
  - ✓ **Dry pea (*Pisum sativum* L.)**
  - ✓ **Grain sorghum (*Sorghum bicolor* L.)**
  - ✓ **Lentil (*Lens culinaris* Medik)**
  - ✓ **Proso millet (*Panicum miliaceum* L.)**
  - ✓ **Sunflower (*Helianthus annus* L.)**
  - ✓ **Spring wheat (*Triticum aestivum* L.)**
- Crops were evaluated at two sites, staggered by one year (2002-2003, 2003-2004).

Site Description

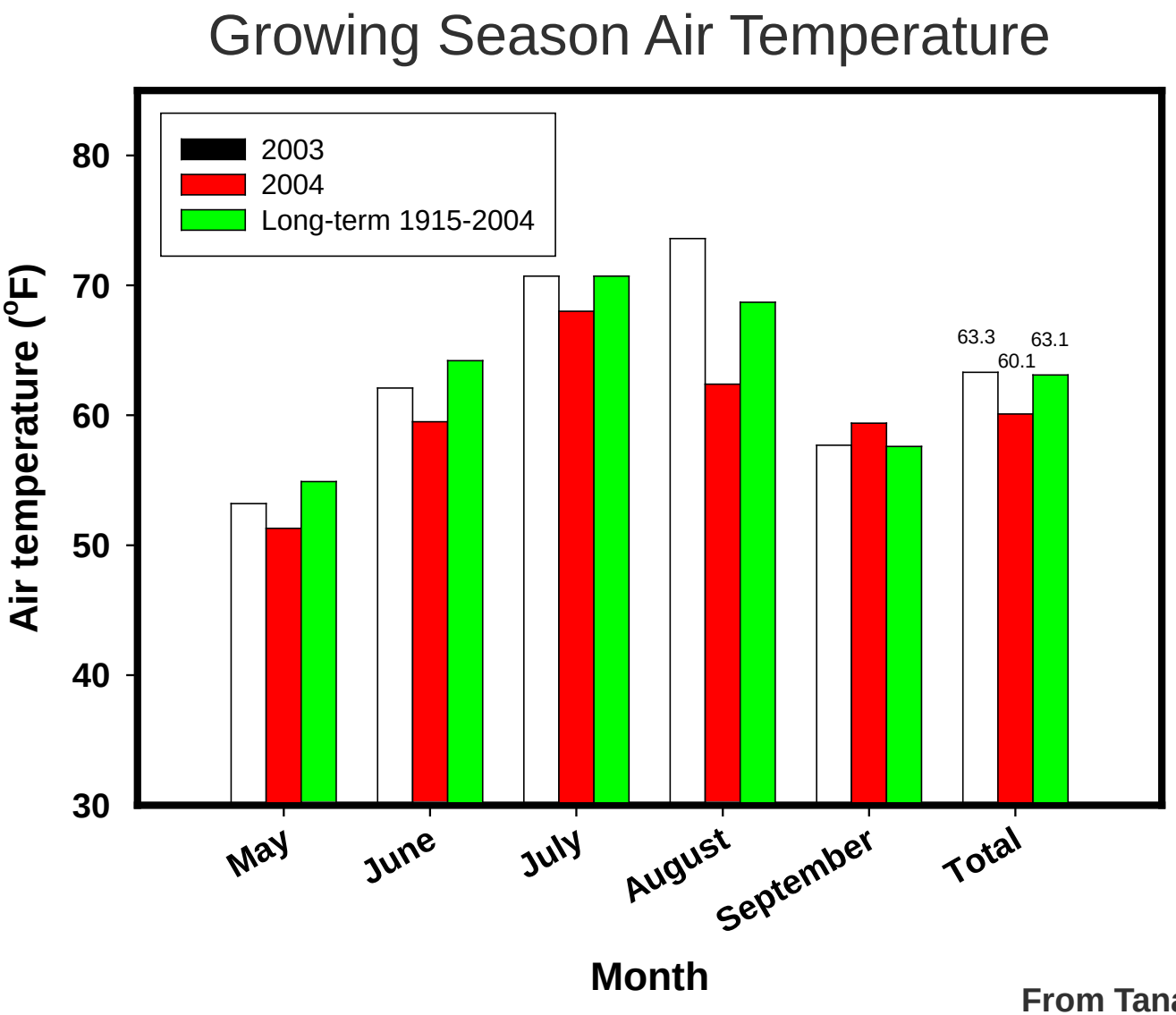
- The experiment was conducted on a nearly level (0-3% slope) Temvik-Wilton silt loam.
- The Temvik-Wilton series consists of very deep, well drained soils that formed in a silty loess mantle overlying glacial till.
- USDA Soil Taxonomy: Fine-silty, mixed, superactive, frigid Typic and Pachic Haplustolls

Growing Conditions



From Tanaka et al. (2007)

Growing Conditions



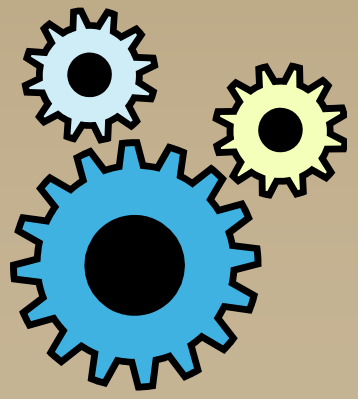
From Tanaka et al. (2007)

Evaluations

- The following evaluations were conducted by a multidisciplinary team of researchers during the project.
  - ✓ Seed and residue yield
  - ✓ Precipitation-use efficiency
  - ✓ Leaf spot diseases
  - ✓ Crop residue coverage of soil
  - ✓ Soil water depletion and recharge
  - ✓ Surface soil properties

Application

Findings from evaluations helped identify crop sequence *synergisms* and *antagonisms*, thereby providing the necessary foundation for developing strategies to sequence crops over a longer period of time.



Application

Information in the Crop Sequence Calculator addresses the…

…***what*** **to grow,**
when **to grow it, and**
how **to grow it…**

…considerations of annual crop sequencing in the context of optimizing economic, social, and environmental goals.

Crop Sequence Calculator

- Information in this program is part of an on-going research effort at the Northern Great Plains Research Laboratory to create more sustainable cropping systems for the northern Great Plains.
- As this effort evolves, additional principles and guidelines will be presented in new versions of the Crop Sequence Calculator.
- No material in the Crop Sequence Calculator may be copied or distributed in part or whole without permission of the research scientists involved.