Soil Water Depletion and Recharge by Diverse Crop Species

Concepts, Research Results,

and Applications

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Water and the Application of Dynamic Agricultural Principles to Cropping Systems

The essence of applying Dynamic Agricultural Principles to cropping systems is making annual crop choices to carry out an integrated long-term strategy that achieves:

- Increased and more stable economic return
- Increased and stabilized soil and land quality
- Reduced vulnerability to climatic, biological, and economic chaos and risk

Water and the Application of Dynamic Agricultural Principles to Cropping Systems

In a water-limited region, excess of seasonal crop water use (evapo-transpiration) over precipitation results in soil water depletion.

In a dryland cropping system, water is typically the most limiting production factor.

Applying Dynamic Agricultural Principles means using a diversity of crop species.

Water use among crops varies significantly, and soil water depletion one year affects water available for next year's crops.

Our research goal was to determine differences among crop species in seasonal soil water depletion and over-winter and what are the principles that would allow us to understand and predict these differences

Soil Water Content Measurements

We used a neutron moisture meter to measure soil water contents.
The active part of this instrument is lowered into a tube in the soil to take readings at approximately weekly intervals.

Some Information about Methods

- **The soil water depletion accounting period was from mid-May to mid-September.**
- **The soil water recharge period was from mid-September to mid-April.**
- **Measurements were made in crops that were grown following spring wheat.**
- **Measurements shown here were made to a soil depth of 6 feet.**

Soil Water Depletion in the Phase III Crop Sequence Experiment

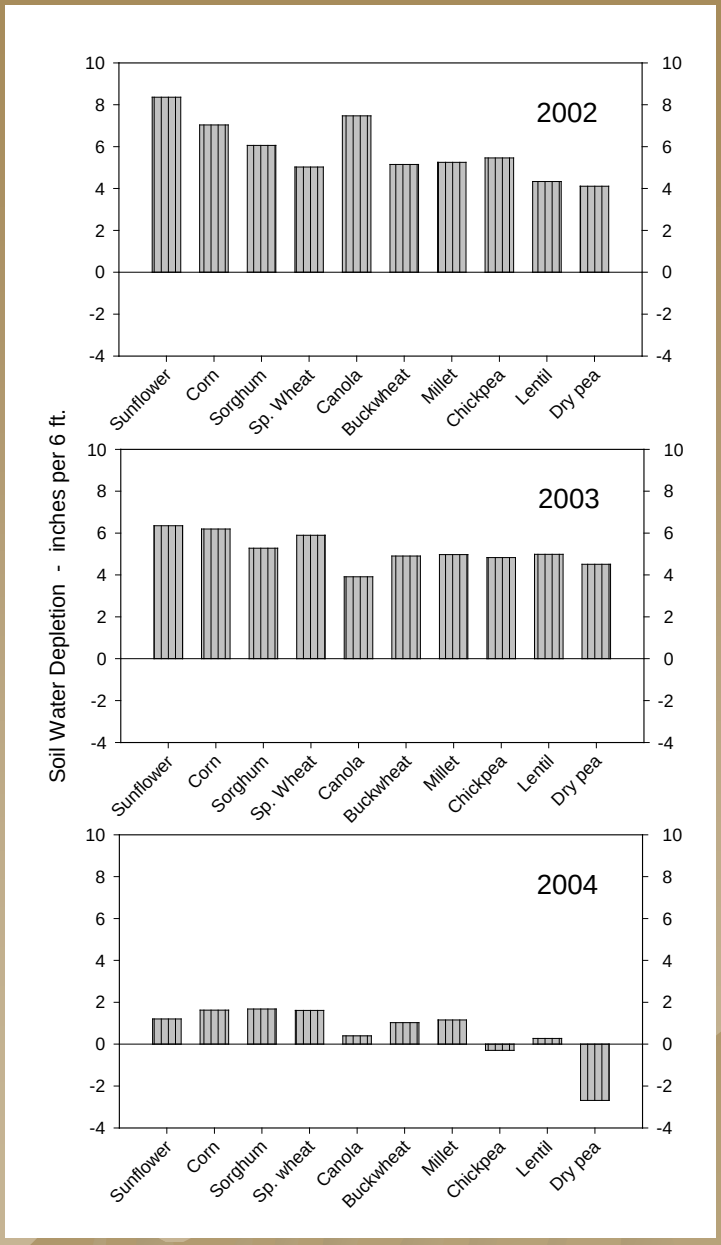
2002 = 7.6 inches

6-mo seasonal precipitation avg. = 12.8 inches

2003 = 10.6 inches

Multiple years of below-average precipitation resulted in low soil water in spring of 2004 and caused soil water depletion to be a smaller part of water use that year.

2004 = 10.4 inches



Soil Water Depletion: 3-Year Averages (inches)

Phase III
Crop Sequence
Experiment:

SUNFLOWER	**5.4**
CORN	**5.0**
Sorghum	**4.3**
SPRING WHEAT	**4.2**
CANOLA	**3.9**
Buckwheat	**3.7**
Millet	**3.8**
Chickpea	**3.3**
Lentil	**3.2**
DRY PEA	**2.0**

Soil water depletion from subsoil (3.0 – 6.0 feet)

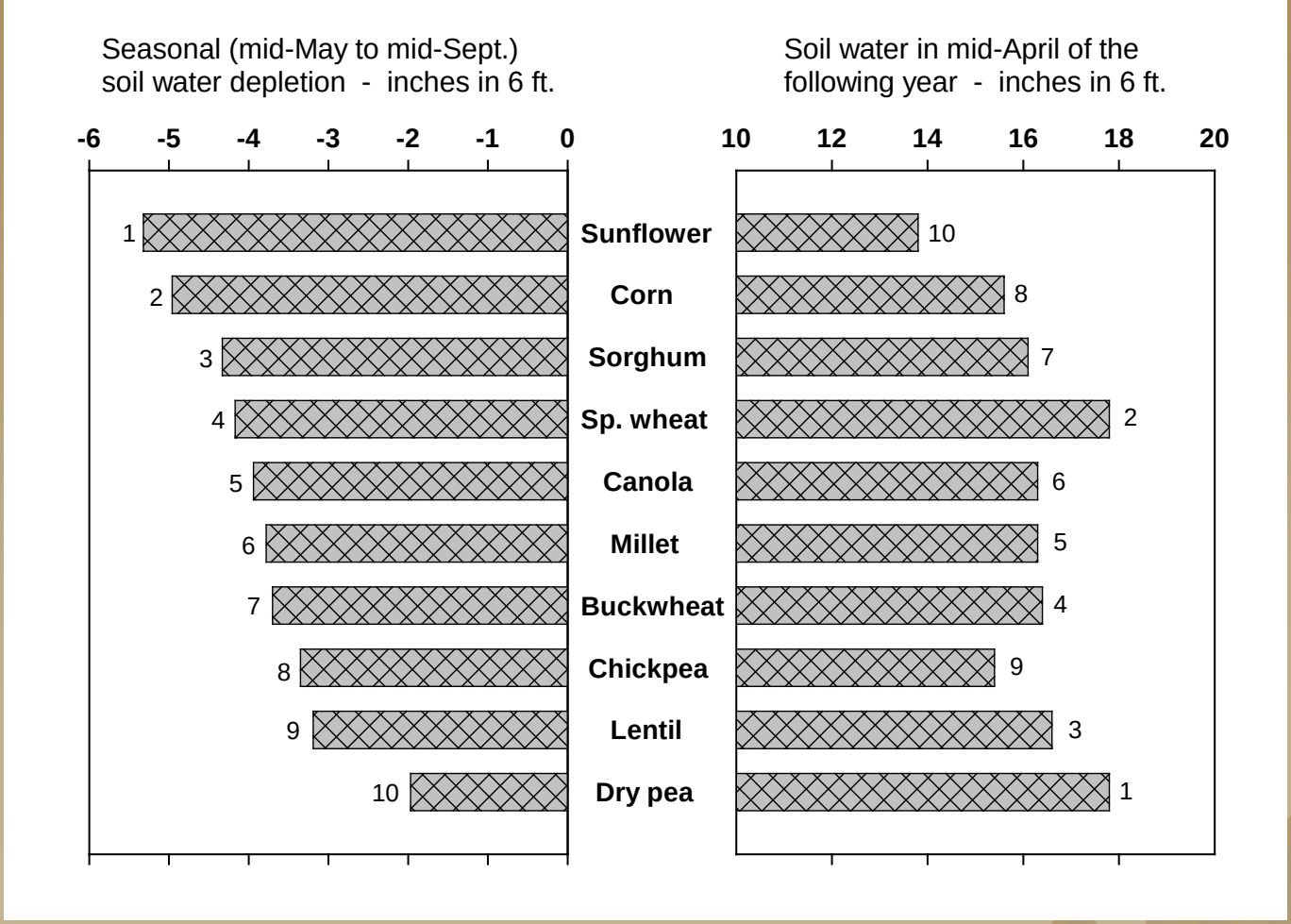
mid-June to 1st Sept., 2002-2003

The mining of subsoil water by a a more deeply-rooted crop like sunflower can often create negative effects on crop production in the following year or years.

	Amount of depletion (inches)	Percent of total depletion
SUNFLOWER	1.97	27.4
CORN	1.02	15.4
SP. WHEAT	1.18	17.0
CANOLA	1.30	19.3
DRY PEA	0.67	12.6

Rank of soil water depletion compared with soil water the following spring

Soil water depletion largely determines how much soil water there will be the next spring, but superior snow-capture by stubble (spring wheat) or poor snow-capture and possibly post-harvest weed growth (chickpea) can modify this.

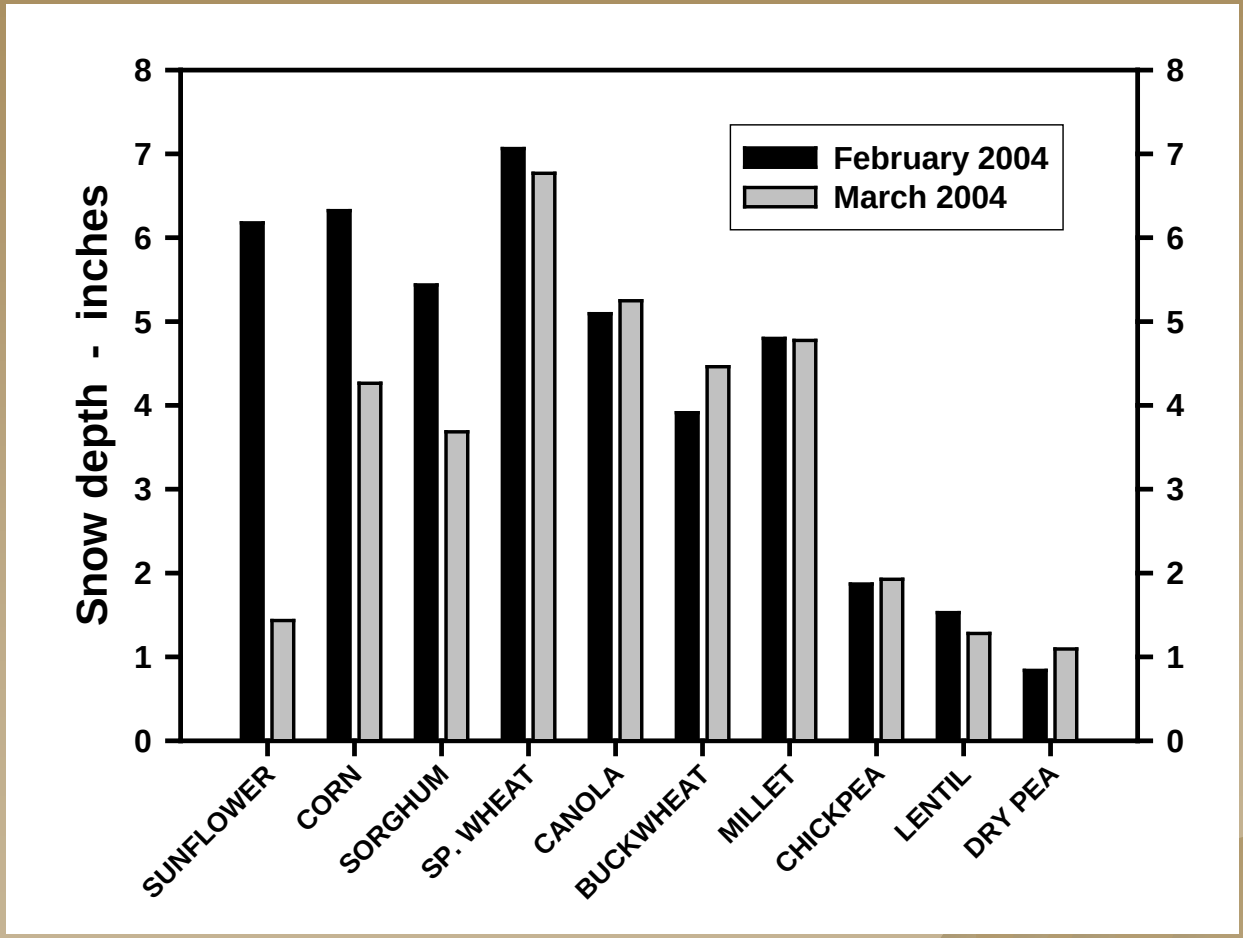


Three-year averages (2002-2004) from Phase III crop sequence project.

Snow Retained by Crop Residues

Depths of Snow Measured in Feb. and Mar. 2004

Spring wheat showed the best snow-holding ability and the pulse legumes, chickpea, lentil, and pea had the least snow-capture. Snow initially captured by sunflower stubble did not persist.



THE FARMERS' BOTTOM LINE:

Soil water depletion and amounts of soil water left in the profile the next spring (inches)

Previous Crop	**Depletion** mid-May – mid-Sept	**Soil water next April** to 6 ft. depth	**Difference from sunflower**
SUNFLOWER	5.3	13.8	0
CORN	5.0	15.6	1.8
SP. WHEAT	**4.2**	**17.8**	**4.0**
CANOLA	3.9	16.3	2.5
LENTIL	3.2	16.6	2.8
DRY PEA	**2.0**	**17.8**	**4.1**

Soil Water Depletion and Water Use Character

Length of active growing season is the best overall guide to the relative amount of soil water depletion. Rooting depth is also an indicator of depletion.

	WATER DEPLETION	SEASON LENGTH	ROOTING DEPTH
SUNFLOWER	heavy	long	deep
CORN	heavy	long	mod. deep
SOYBEAN*	mod. heavy	mod. long	mod. shallow
SP. WHEAT	medium to mod. Light	mod. short	medium
CANOLA	mod. heavy to mod.light	medium but variable	medium
DRY PEA	light	short	mod. shallow

* Soybean was grown in the Phase II crop sequence experiment.

Summary of Soil Water Depletion Results

Comparative soil water depletion is the best overall guide to the relative amount of soil water available the next spring. However, over-winter soil water recharge can modify this as has been shown in previous slides.

Summary of results from Phase II (1998-2000) and Phase III (2002-2004) crop sequence projects:

Phase II	Phase III	Soil water depletion
Sunflower	Sunflower	heaviest
	Corn	heavy
Soybean		moderate to heavy
Canola	Canola	variable
Dry bean		moderate
Spring wheat	Spring wheat	moderate
Flax		moderate
Barley		moderate to light
	Lentil	light
Dry pea	Dry pea	light

Applications

The heaviest water-using crop we measured, sunflower, left up to 4 inches less water in the soil in spring of the next year compared to the least water-using crop, dry pea.

This can have negative effects on production of crops following heavy water-users in years with limited rainfall.

This is a well-known on-field effect.

There can be significant, larger-scale off-field and off-farm effects of greater and lesser water use and soil water depletion by crops which have been less studied by researchers.

Soil, Field, Land, Stream and Watershed: SCALE MATTERS

Positive (+) and negative (-) effects of lesser or greater water use and hence, lesser or greater soil water depletion at various scales: illustrated by dry pea vs. sunflower

LESS Water Use by DRY PEA	MORE Water Use by SUNFLOWER	Where
(+) More water for following crops	(-) Less water for following crops	on-field
(-) Less trafficability in lower areas	(+) More trafficability in lower areas	on- and near-field
(+) More water for animals, wildlife	(-) Less water for animals, wildlife	off-field
(-) More flow of nutrients and chemicals; more erosion	(+) Less flow of nutrients and chemicals; less erosion	off-field