Water Quality and Management Projects (NP 201) at USDA-ARS, Sidney, MT

Research Overview

Scientists with the Agricultural Systems Research Unit at the Northern Plains Agricultural Research Laboratory in Sidney, MT have initiated two major, multi-year irrigation studies exploring the impact of tillage, irrigation methods, crop rotations and cultural management on crop yield and quality, soil quality, soil water use efficiency, nitrogen use efficiency, and weed competitiveness.

This knowledge will aid in the development of advanced soil, crop and water management techniques to use rainfall more effectively and improve the effectiveness of irrigated agriculture in the region.

Techniques developed from both studies will also enhance profitability and environmental benefits for producers throughout the Northern Great Plains.

1 Precision Agricultural Irrigation Systems, Tillage and Residue Management Technologies in the Northern Great Plains

Purpose / Objectives

The purpose of these experiments is to develop information on the effect of crop sequences, tillage and irrigation methods on crop yield and quality, foliar disease incidence and weed distributions on heavy soils. The project looks at irrigated cropping systems under precision, self-propelled linear move irrigation systems with joint water and chemical application capabilities.

Specific objectives are:

1) to develop irrigation management and cultural practices that promote water use efficiency, reduce negative effects of soil compaction, and enhance environmental benefits;

2) to develop farming practices that minimize soil disturbance and compaction essential for maintaining soil structure and eliminating the need for expensive post-harvest soil treatments, and

3) to examine the interaction between irrigation methods, crop rotations, and tillage on yields, pest problems and soil water movement.

Project Description

This is a five-year project begun in 2003. Under the project, ARS researchers will be evaluating modified tillage interactions (conventional and strip till) under two irrigation methods (MESA - mid-elevation sprinkler, above canopy, and LEPA - low-energy precision application, below canopy) on an 8-acre plot area with four sugar beet/barley rotations common to the region. The research plots are located on land made available by Montana State University under a cooperative agreement that includes use of some shared equipment.

ARS scientists are developing the precision irrigation hardware and software needed for the study. The research focus is on assessing the environmental impacts of cultural practices and improved management of water, nutrient and chemical applications under precision irrigated cropping systems. Elements being looked at for include yields, crop quality, infiltration, diseases, soil quality and management guidelines.

Progress / Impacts

2003, First Year - Detailed soil sampling done. Irrigated barley crop planted across all plots to provide background information on yield variability.

2004, Second Year - First year of the irrigation and tillage experiment. Existing linear move irrigation equipment was modified for precision irrigation with dual MESA and LEPA systems installed. First set of crop rotations planted and harvested.

While still early in the study, there is already growing interest in the use of a custom built strip tiller designed specifically for sugar beets under center pivot irrigation. In its first year of use, the strip tiller significantly reduced fall field prep work without affecting subsequent yields. The modified tiller uses a "side dress" system that applies the fertilizer at the same time as tilling. Under the system, the fertilizer is injected next to the beet seed, reducing the amount of fertilizer needed and cutting the number of field passes from as many as 7 or 8 to as little as one. The system also provided significant wind protection for beet seedlings as well as water and fertilizer savings. The strip tiller also contributed to fuel and time savings, along with reduced soil compaction and erosion.

Custom Strip Tiller

2 Relationships Between Cropping Sequences and Irrigation Frequency Under Self-Propelled Irrigation Systems in the Northern Great Plains

Purpose / Objectives

The purpose of these experiments is to develop information on the relative effect of crop sequences, tillage, and irrigation frequency on water use for various crops, yields and crop quality, foliar disease incidence and weed distributions on sandy soils. The project uses a linear move irrigation system to develop and test precision water and chemical application systems and to assess their use in high value irrigated cropping production systems and their role in improving water and soil quality and ecologically-sound pest management practices and technologies. Because plot sites in this project have not been previously irrigated it also provides researchers with an opportunity to track transitional changes in soil properties.

Specific objectives of this research are:

1) to determine the relative crop yields under various cropping sequences and water use efficiency from two irrigation frequencies;

2) to monitor the effect of irrigated crop production on soil properties in the transition from dryland to irrigated conditions (characterize changes in soil properties, soil structure, microflora, microbes, OM, disease incidence and weed emergence [species]);

3) to test and evaluate precision self-propelled irrigation techniques and establish management criteria for sandy soils in the semi-arid Northern Great Plains, and

4) to develop procedures for wireless sensor-based irrigation scheduling of precision self-propelled irrigation systems - tied to a computer, in combination with on-site weather data, remotely sensed data, and grower preferences.

Project Description

This is a five-year project begun in 2003 on land made available to ARS by North Dakota State University under a cooperative agreement. Under the project ARS researchers are evaluating six rotations of sugar beets, potatoes and barley under two irrigation frequencies (15 and 30 mm of water use with mid-elevation sprinklers) on a linear move irrigation system on 48 sandy soil plots. Minimum tillage techniques are also being used whenever possible.

ARS scientists are developing the precision irrigation hardware and software needed for the study. The research focus is on assessing the environmental impacts of cultural practices and improved management of water, nutrient and chemical applications under precision irrigated cropping systems using sugar beet, potato and small grain crop sequences. Researchers are looking at yields, crop quality, infiltration, disease, carry over effects of different rotations, soil compaction, soil quality changes, weeds, and effectiveness of irrigation management with sensor feedback, using remote sensing and other advanced information collection techniques.

Progress / Impacts

It's too early in the research effort to identify any impacts; however, the following progress has been made:

2003, First Year - Initial soil sampling completed and electrical conductivity maps developed.

2004, Second Year - Installation of the irrigation water delivery system completed and tested, with a large capacity well drilled and pump installed. The linear move irrigation system has been erected and final adjustments made as well.

2005, Third Year - First set of crop rotations planted.

Supporting Research: Compaction, Disease, Soil Quality, Nitrogen

Nitrogen Management on Malt Barley

Nitrogen management is a major factor in the quality of sugar beets and small grains. The resulting increased yields can lead to excessive applications which can, in turn, contaminate surface and subsurface water resources. Excessive applications can also lead to high protein levels in malting barley that make it unfit for brewing facilities.

Research at Sidney ARS is looking at both fertility and water management research for integrating irrigated six-row malt barley with sugar beets. Fertility management examines the effect of various nitrogen fertilizer rates and timing on protein and other quality parameters, while water management focuses on the efficient use of irrigation water and energy to optimize grain production through emerging site-specific fertilization technologies. The project just completed its first year.

Soil Quality / Aggregation

The use of cover crops to boost soil nitrogen and organic matter and conserve soil moisture, and the promotion of soil aggregating fungi and bacteria to enhance water infiltration and plant root growth are the focus of two supplemental research efforts at Sidney ARS. Cover crop research is comparing different tillage (no-till and conventional till), crop rotations (continuous barley, barley-fallow, and barley-pea), and irrigation (comparing irrigated vs. nonirrigated) as part of the larger irrigated cropping systems project (#2).

Researchers at Sidney ARS have also helped isolate and identify a group of soil fungi (basidiomycetes) that promote soil aggregation, another indicator of soil quality. Sidney scientists have developed a method to detect and quantify the fungi to determine the impact various irrigated/dryland cropping systems may have on those populations. Sidney researchers are also studying soil bacteria with similar soil aggregating properties that may prove more resistant to tillage.

Disease Management

Cercospora leaf spot is the most important foliar disease affecting sugar beets. Pathogen pesticide resistance and increased environmental concerns regarding pesticide leaching into groundwater have prompted Sidney ARS researchers to begin looking at new - and old - ways to manage plant diseases such as Cercospora (and soon, net blotch of small grains). Prior to the arrival of chemical controls, crop rotations, plant diversity, livestock use and other cultural practices were often used to contain damage. Today, biological control efforts are an added option with researchers at Sidney ARS studying the biology of the Cercospora fungal disease agent; identifying alternate hosts; identifying potential biocontrol agents and studying the incidence of disease agents under various irrigation systems.

Already this research effort has yielded two major results:

1) determined that safflower is an alternate host for Cercospora using a technique developed at the lab,

2) identified an enzyme that can detoxify a protective toxin in Cercospora (research led to patent application and interest in a Cooperative Research and Development Agreement).

Soil Compaction Studies

Soil compaction from tractors, harvesting equipment and implement wheels traveling over moist soils, can reduce yields up to 50% and can lead to excessive runoff and soil erosion, among other ills. In particular, soil compaction can contribute to the lateral redistribution of irrigation water and chemicals from high to low-lying areas where leaching of pollutants to the water table can occur.

New field experiments to quantify soil compaction under various dryland and irrigated crop sequence, tillage and irrigation management systems are being established at Sidney ARS, with the goal of developing sustainable management practices that prevent or reduce soil compaction on the Northern Great Plains.

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