Improving precipitation use efficiency in dryland cropping systems

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Final Report

Overview

Dryland agriculture (i.e. non-irrigated crop production in arid and semi-arid regions) represents 44% of the global agricultural land area and more than 90% of wheat production in the United States. The spatial extent of dryland agriculture is anticipated to increase over time. In the Western U.S., large areas are experiencing reductions in available irrigation water due to climate change and the redirection of water to rapidly growing urban areas. In addition to increased demand for water, the frequency and intensity of both droughts and intense rain events are expected to increase in the region with climate change.

Increasing soil carbon levels has the potential to improve cropping system resilience in the face of climatic variability. Soil carbon can foster soil aggregation, increase soil porosity and improve water infiltration rates, thereby increasing precipitation capture efficiency. Soil aggregation is also a critical variable controlling soil wind erosion susceptibility as the size and strength of soil aggregates affects how easily they can be carried away by the wind. Soil residue cover and soil moisture near the surface of the soil are other important factors that can influence wind erosion. In dryland cropping systems, wind erosion is a major force that can influence long-term soil quality and productivity.

The intensification of crop rotations under no-till management provides an opportunity to increase organic carbon and foster aggregation in soil surface layers. Due to limited rainfall and high evapotranspiration potential, the dominant rotation in the region is a two-year winter wheat-fallow rotation. The 14-month fallow period increases soil water storage relative to continuous wheat and produces more consistent wheat yields. However, the fallow period is highly inefficient and stores at most 25% of incoming precipitation for the following wheat crop. In addition, the fallow period has contributed to the evolution of herbicide resistant weeds and increases wind erosion susceptibility. The adoption of no-till management has reduced evaporative losses due to increased surface residues and allowed for a reduction in the frequency of fallow in rotations and diversification to include corn, millet, or forage crops.

In no-till cropping systems, rotation impacts on soil carbon and soil structure are concentrated in surface layers where it is most difficult to measure soil moisture dynamics. It is in this surface soil layer that soil aggregation dynamics influence wind erosion susceptibility. Utilizing a long-term cropping systems experiment, we analyzed the relationships between crop rotation diversity and soil moisture dynamics to increase our understanding of the aggregation process and linkages to wind erosion susceptibility.

Activities

We collected data from the 30-year old Dryland Agroecosystem Project (DAP) research sites near Sterling, Stratton, and Walsh, that represent a gradient of potential evapotranspiration across eastern Colorado. Graduate student, Cassandra Schnarr, collected monthly soil moisture samples from 0-2.5cm, 2.5-5cm, 5-10cm depths from wheat-fallow, wheat-corn-fallow, continuous grain crop, and continuous forage crop treatments at all three DAP sites from March through October 2014. Soil samples were also collected for dry aggregate strength and size distribution, which are key indicators of soil susceptibility to wind erosion. Wind erosion research and dry aggregate fraction analysis was conducted in collaboration with Dr. John Tatarko, USDA-ARS Agricultural Systems Research Unit.

Findings

Preliminary results suggest that the current or previous year's crop had a stronger effect on both soil moisture and soil aggregation than longer-term cropping system legacies. For example, fallow periods following a winter wheat crop had higher surface soil moisture and a lower proportion of smaller soil aggregates susceptible to wind erosion than fallow periods following corn. This is likely influenced both by the longer fallow period following winter wheat and the quality of the residue during the fallow period (Figure 1).

Figure 1. Limited spring residue cover following corn in a no-till crop rotation near Stratton, Colorado (left), may leave soil vulnerable to evaporation and wind erosion. In contrast, dense residue following winter wheat harvest (right) can protect soil from wind erosion and retain soil moisture.

In addition, we continued construction of dual-probe heat-pulse sensors in collaboration with Dr. Jay Ham to continuously monitor soil moisture dynamics near the soil surface within the DAP sites (Figure 2).

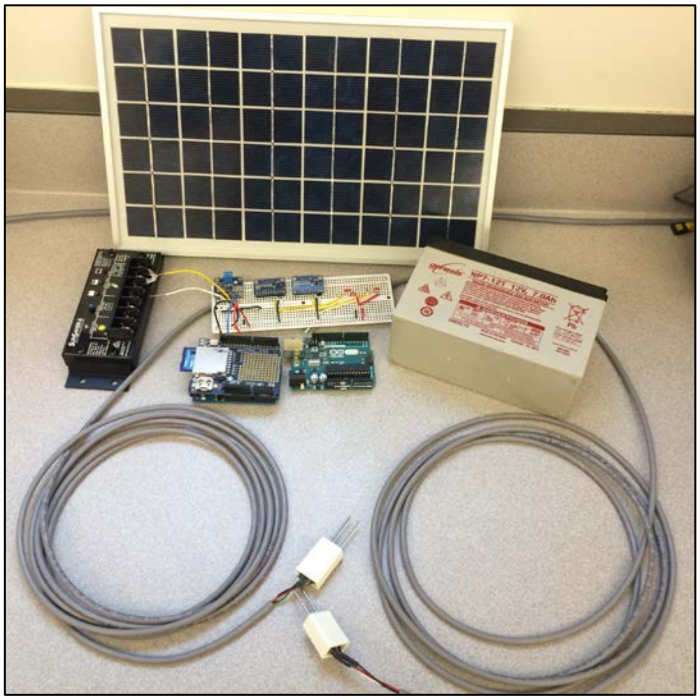

Figure 2. A constructed dual-probe heat-pulse sensor for continuous soil moisture measurements. These sensors combine low-cost Arduino microprocessors with heat conducting and sensing probes that are powered by a small solar panel.

Outcomes and Impacts

Presentations

Schnarr, C., M. Schipanski, J. Tatarko. Cropping system sffects on wind erosion potential. Abstract accepted for presentation at ASA/CSSA/SSSA meeting, Phoenix, AZ, November 7-9, 2016.

Schnarr, C. and M. Schipanski. 2016. Keeping the farm on the farm when the wind blows. Technical Bulletin, Wheat Field Days 2016. Colorado State University Agricultural Experiment Station.

Additional funding leveraged

USDA NIFA Coordinated Agricultural Project. 2016-2020. Sustaining agriculture through adaptive management to preserve the Ogallala Aquifer under a changing climate. Lead PI M. Schipanski, coPIs E. Kelly, R. Waskom, C. Rice, C. West, K. Wagner, B. Auvermann, C. Ray, M. Marsalis, J. Warren, B. Guerrero. ($9,800,000)