Reprinted from *1999 Columbia Basin Agricultural Research Annual Report. Spec. Rpt. 999,* pp. 74-80, 1999
Oregon State University in cooperation with USDA-Agricultural Research Service, Pendleton, OR

INSTRUMENTATION OF THE LONG–TERM CROP RESIDUE PLOTS FOR HYDROLOGIC AND SOIL EROSION EVALUATION

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Introduction

Scientists with the U.S. Department of Agriculture (USDA)-Agricultural Research Service (ARS), Columbia Plateau Conservation Research Center (CPCRC), and Oregon State University (OSU), Columbia Basin Agricultural Research Center (CBARC), are expanding the scope of research conducted within a long-term crop residue study begun in 1931 (Rasmussen and Smiley, 1994). In this study, attention focused on the relative merits of various crop residue and fertilizer management strategies in the production of winter wheat (Rasmussen and Parton, 1994). Some of the most important research findings in intermountain, western U.S., cropland production result from crop yield and soil attribute collected in this study (Rasmussen et al., 1998). Most recently, a team of ARS and OSU scientists led by John Williams (ARS) and Bill Payne (OSU) began the process of demonstrating how these long-term treatments effect soil hydrology, water quality, and crop water-use efficiency in a number of the treatments (Table 1). This paper describes the instrumentation and techniques used to collect data on weather, runoff, infiltration, soil temperature, and soil erosion.

Materials and Methods

We collected a wide range of weather related data. Two recording raingages, a weighing and a tipping-bucket, electronically recorded 15-min rainfall intensity. The weighing raingage also recorded rainfall data on a strip chart. A standard raingage served as a backup to the recording raingages. Rainfall depths must be measured and recorded by a person at the site. We checked this raingage on a frequent basis during runoff events for quality assurance/quality control (QA/QC) of rainfall records. In 1997–1998, we found that all but the largest storms lasted less than one hour and that runoff from many of the treatments occurred for 20 min or less within the rainfall period. By measuring rainfall intensity in 15-min intervals, we hoped to more accurately describe the weather conditions that create runoff. Wind speed, air temperature, solar radiation, and relative humidity were also recorded 1.5-m above the soil surface automatically every 15 min using a Davis Instrument Crop.-GroWeather System*. These measurements provided information about the effects of crop residue management strategies on crop water-use efficiency (Fig. 1).

We collected extensive moisture and temperature data at 15-min intervals at several depths through the soil profile in the 6 percent slope, spring-burn, 0 kg/ha fertilizer treatment (Fig 2.). These data, in combination with the rainfall and runoff data, will help us develop our understanding of crop residue management strategies on crop-water relations and soil physical properties (heat exchange and water or solute balances). Time domain reflectometry (TDR) probes (Dalton and Van Genuchten, 1986) measured volumetric moisture at soil depths of 20, 40, 80, 160, 320 mm. Neutron attenuation measurements determined soil moisture at deeper depths after runoff events (Gardner, 1965) at 300 mm intervals to a depth of 1.8 m. Core samples are

* Mention of manufacturer or brand names does not constitute endorsement by USDA or its employees.

periodically collected to measure solute distribution in the soil profile. Thermisters recorded soil temperatures at 10, 20, 40 80, 160, 320 mm depths (Taylor and Jackson, 1965). We also installed two frost-tubes in all of the treatments to measure the depth of frozen soil before and after runoff events and to provide a rapid assessment of the soil frost conditions (Fig. 3). These tubes must be manually read and the information recorded (Ricard et al., 1976).

We installed a system to measure the runoff water resulting from rainfall, snowmelt—or a combination thereof—and soil erosion. Lister furrows routed runoff from within each treatment to drop–box weirs (Bonta, 1998) that controlled runoff to provide a depth measurement (stage depth) (Fig. 4). Stage depth was converted to a volume per unit time value. The drop-box weir was designed to accurately measure low volume runoff that is heavily laden with eroded material. We measured stage depth using two electronic methods, Global Water* weir sticks (Fig. 5) and Lindhal* sonic range finder. To check the accuracy of the electronic measurements, we collected timed samples (grab samples). The electronic samplers record depth values every 2 min. From this data we will determine the total volume of runoff, the amount of rainfall required to initiate runoff, and the length of time after rainfall begins to the start of runoff. We also measured the amount of runoff generated within the lister furrow separately from the cultivated treatment area (Fig 6).

We installed Sigma* Sediment samplers to collect samples of material washed from the treatments plots (Fig. 2). A tube installed immediately below the weir mouth collected a sample of mixed bedload and suspended material. The sediment samplers were triggered by a liquid-level switch to start collecting samples when runoff begins (Fig. 7). Samples (50 ml) were collected from a catch basin below the weirs (Fig. 8), beginning with the onset of runoff and once every 20 min thereafter until flow ended. We chose the sampling interval based on observations in 1997–1998 of runoff duration and the number of samples that we could reasonably process, store, and analyze given our resources. The samples were analyzed for total eroded material that includes mineral soil (silt, sand, clay), suspended solids (total N, total C, and total P), and dissolved solids and nutrients (PO_4, NO_3, NH_4) (Brakensiek et al., 1979; Stevenson, 1982; Keeney and Nelson, 1982; Nelson and Sommers, 1982; Olsen and Sommers, 1982). To insure QA/QC of the automatically collected, eroded material, we analyzed the grab samples used for runoff QA/QC for the same eroded material components.

Our goal was to establish an automated data-collection system to meet our QA/QC standards but requiring minimal maintenance. The plots were visited daily to insure that weeds did not block the weirs and that water ran from the lister furrows into the weirs and not into rodent holes. During runoff events lasting for more than one hour, we collected at least one timed sample from each plot generating runoff. We also monitored the ditches carrying water away from the weirs to insure they remained open. Data from electronic recording devices were downloaded and checked for anomalies after every storm resulting in runoff from two or more treatments.

Conclusion

The automated system now in place insures that we will not miss collecting data resulting from unexpected rainstorms, day or night. This system reduces the amount of work hours required to monitor weather patterns and forecasts as well as time spent awaiting storms that might create measurable runoff from two or more treatments.

Acknowledgments

Installing and maintaining the equipment for this effort required a team effort. In addition to the authors, the following individuals have contributed considerable time and energy. Steve Albrecht, Bob Correa, Roger Goller, Daryl Haasch, and Joy Matthews participated in the weir installation. Daryl Haasch, Joy Matthews and Stephen Osborn were responsible for day-to-day plot maintenance and data downloading. Bob Correa developed the liquid level switch for the Sigma Samplers, a task for which he received special recognition in the form of a USDA-ARS Spot Award. In the laboratory, Tami Johlke and Amy Baker processed runoff samples to determine erosion and water quality.

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Table 1. Long–term crop residue treatments instrumented for evaluation of runoff and erosion, Agricultural Research Center, Pendleton, OR, 1998–1999 erosion season.

Slope (%)	Crop status	Burn treatment	Fertilizer
6	In crop	No burn	Manure
6	In crop	Spring burn	0 kg/ha
6	In crop	Fall burn	0 kg/ha
6	In crop	No burn	90 kg/ha
6	Standing stubble	No burn	Manure
6	Standing stubble	No burn	90 kg/ha
2	In crop	No burn	Manure
2	In crop	Spring burn	0 kg/ha
2	In crop	Fall burn	0 kg/ha
2	In crop	No burn	90 kg/ha
2	Standing stubble	No burn	Manure
2	Standing stubble	No burn	90 kg/ha

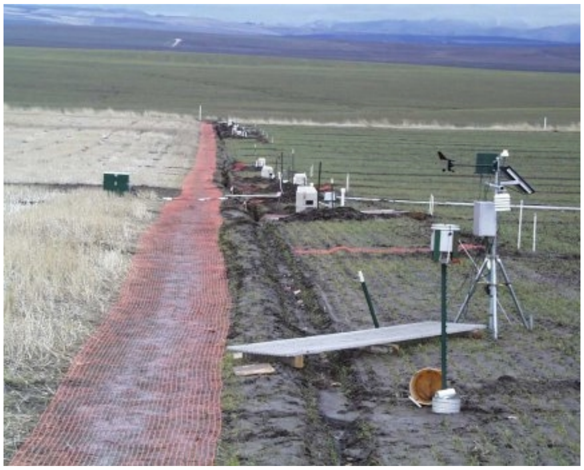

Figure 1. Crop residue study site. Plots at left of photograph are in standing crop residue, plots on the right are current year winter wheat crop. Instrumentation in the foreground is on a 6 percent slope, and the cluster of instruments at the far end of the red walkway are on a 2 percent slope. The box in stubble holds data-loggers for thermister and TDR probes. GroWeather* weather station and a standard raingage are in the foreground. Agricultural Research Center, Pendleton, OR, January 1999.

Figure 2. Walkway leads to TDR and thermister probes in the plot. Sediment sampler and weir are in the foreground. Agricultural Research Center, Pendleton, OR, January, 1999.

Figure 3. Two frost–tubes are in-place in the northwest corner of each plot. Frost depth is indicated by a change in color of the material in the tube. Agricultural Research Center, Pendleton, OR, January 1999.

Figure 4. Water flows into the collection trough from lister furrows and is directed into the drop-box weir in the center of the photograph. A plexiglass cover protects the flow in the weir from strong winds and prevents clogging by wind-blown weeds. The 2.5-in. pvc pipe leads to stilling wells for the depth sensors and liquid-level switch. Agricultural Research Center, Pendleton, OR, January 1999.

Figure 5. Global Water weir stick measured and recorded stage depth in the weir. Sufficient memory existed to make measurements every 2 min for 8 d. Agricultural Research Center, Pendleton, OR, January 1999.

Figure 6. Grab samples were collected from the lister furrows that direct water and eroded material from the treatment area (to the right of the furrow). The purpose of these samples was to separate treatment effects from furrow effects. Agricultural Research Center, Pendleton, OR, January 1999.

Figure 7. Liquid-level switch on the stilling well used to sense flow and start the sediment sampler. Agricultural Research Center, Pendleton, OR, January 1999.

Figure 8. Catch basin used to capture sufficient runoff for collection of 50 ml sample by sediment sampler. The position and size of the basin were designed to provide a thoroughly mixed runoff sample. Agricultural Research Center, Pendleton, OR, January 1999.