Complex Terrain and Ecological Heterogeneity (TERRECO): Evaluating Ecosystem Services in Mountainous Landscapes

Analysis and Modeling of soil hydrology under different soil additives in artificial runoff plots

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Introduction

The impact of monsoon events during June and July in the Korean project region (Haean Basin near the North Korean border in the northeastern part of South Korea) plays a key role for leaching and groundwater pollution risk by agrochemicals. Therefore, the project investigates the main hydrological processes in agricultural soils under field conditions on different scales (plot, hillslope and catchment) and laboratory conditions. Soil hydrological parameters were analyzed in runoff plots using different soil additives (Polyacrylamide (PAM), Biochar). These soil additives are known for prevention of soil erosion and nutrient loss as well as increasing of water infiltration, aggregate stability and soil fertility. Soil hydrology in the unsaturated zone on plot scale will be modeled using Hydrus 1D/2D/3D and on catchment scale with SWAT 2005 (Soil water Assessment Tool).

Methods

Tensiometers were installed in upper (4th interrow) and bottom part (11th interrow) of the runoff-plots in 20, 40 and 60 cm depth in each treatment (PAM, Biochar, PAM + Biochar and Control). Pressure heads were read daily.
TDR-Sensor ECH$_2$O was installed during the tensiometer measurement for measuring the water content in the topsoil (5 cm depth) of each treatment row next to tensiometers. The infiltration rate was measured by double ring infiltrometer for all characteristic horizons. Water retention curve was analyzed in laboratory in soil cores using ceramic plates for all characteristic horizons.

Research area

The Haean Catchment is characterized by intense agricultural land use. The hillslope areas are dominated by dry land farming (cabbage, potatoes, radish) whereas, in central parts of the basin rice paddies are the dominant land use. The intense fertilizer input has a strong impact on water quality of the Lake Soyang which provides freshwater for the population of Seoul. Furthermore, high erosion rates due to the monsoonal storm events are a crucial problem within the Haean Catchment.

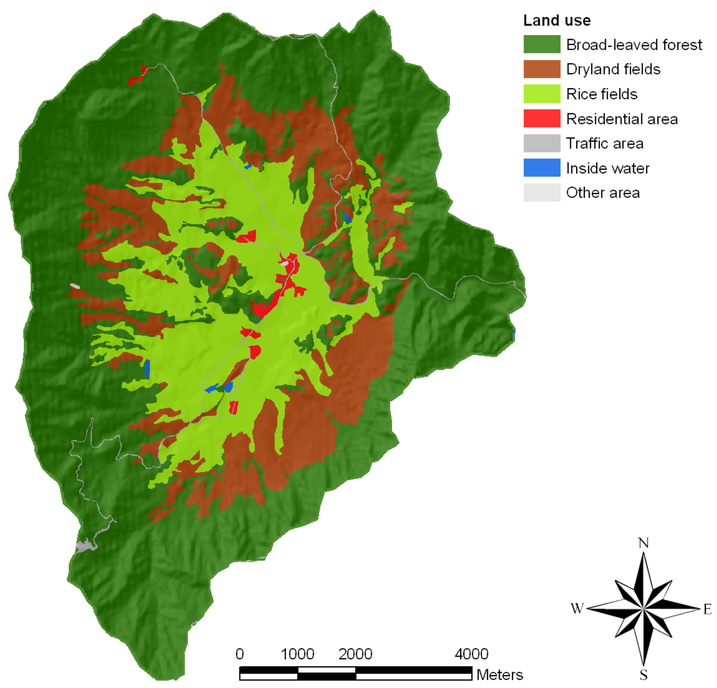

Figure 1 Landuse map of Haean Catchment

Prelimenary Results:

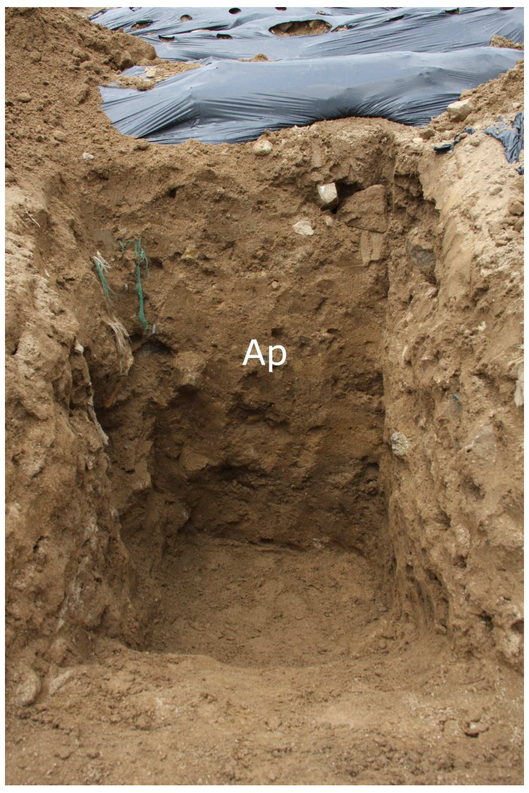

Photo 1 Soilprofile Plot 1

Photo 2 Soilprofile Plot 2

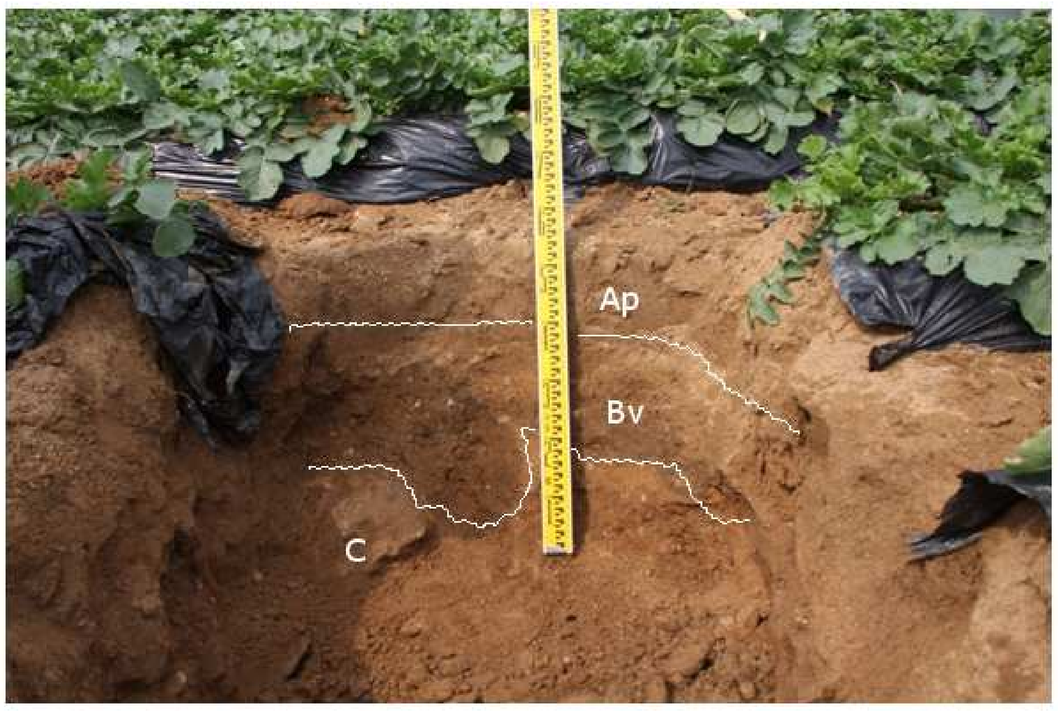

Photo 3 Soilprofile Plot 3

Photo 1-3 Typical agricultural soils in Haean Catchment. Sandy soil (Ap Horizon) is added yearly for compensating soil erosion losses during monsoon season.

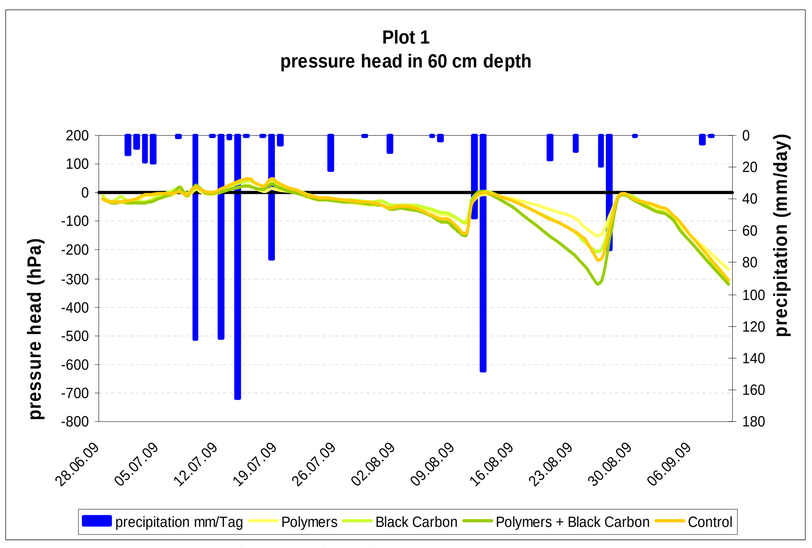

Figure 2 Pressure heads in Plot 1

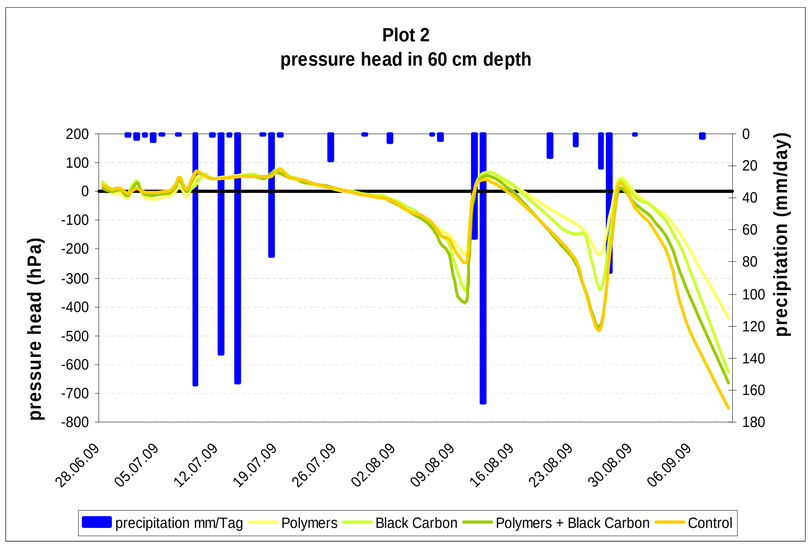

Figure 3 Pressure heads in Plot 2

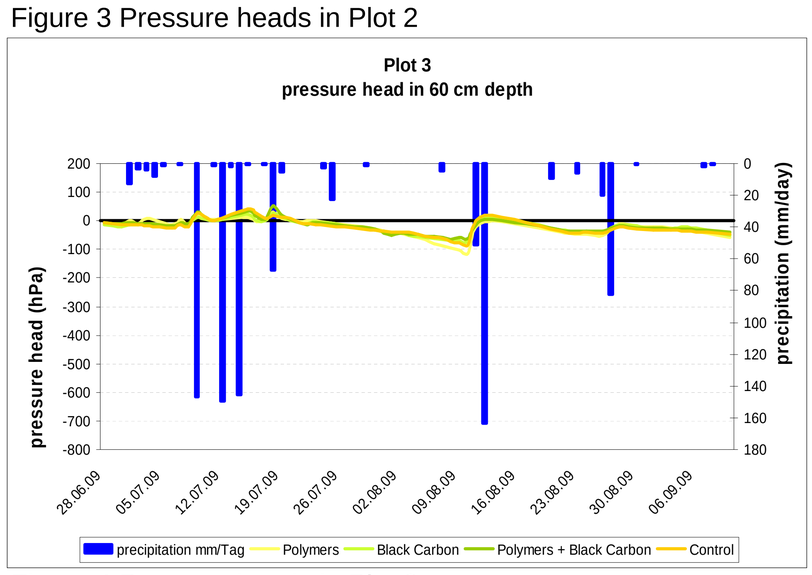

Figure 4 Pressure heads in Plot 3

In Figure 2 - 4 the pressure heads measured in treatment subplots in 60 cm depth are given. After heavy rain events soils in all plots show saturated conditions, independently of soil type and texture. Differences between treatments in wet seasons are negligible.

During dry periods drying processes are highly variable with respect to soil texture.
The soil in Plot 1 is characterized by homogenous sandy material (middle to coarse sand). Plot 2 shows high pressure heads due to the silty – loamy soil texture.

As expected the yellow line of PAM treatment in Plot 1 and 2 show that pressure heads are lower than in other treatment plots. In comparison to Figure 2 and 3, Figure 4 shows only negligible differences between treatments.

Hence, differences might be more based on the influence of spatial variability than on treatments.

Modeling with Hydrus 3D

The dominant land management form of dryland farming in Haean, which is characterised by row planting and row covering by foil will be modeled on plotscale with Hydrus 3D. These planting systems have a huge influence on water infiltration patterns, water dynamics and flow paths.

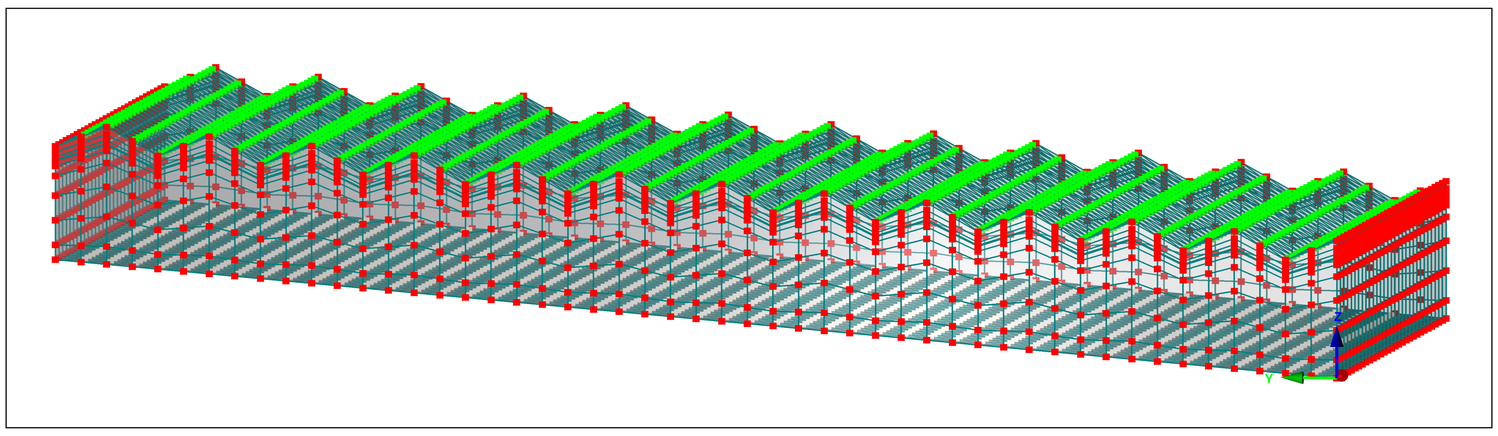

Figure 5 Hydrus 3D Model with typical agricultural fieldsite topography

Modeling with SWAT 2005 (Soil and Water Assessment Tool)

On catchment scale Haean Catchment environmental state variables and fluxes will be modeled with the semi-distributed SWAT2005 model. Thus, environmental and agricultural management impacts on water quality (nutrient, sediment and pesticide transport), percolation, discharge and soil erosion can be analysed by long term simulation scenarios.

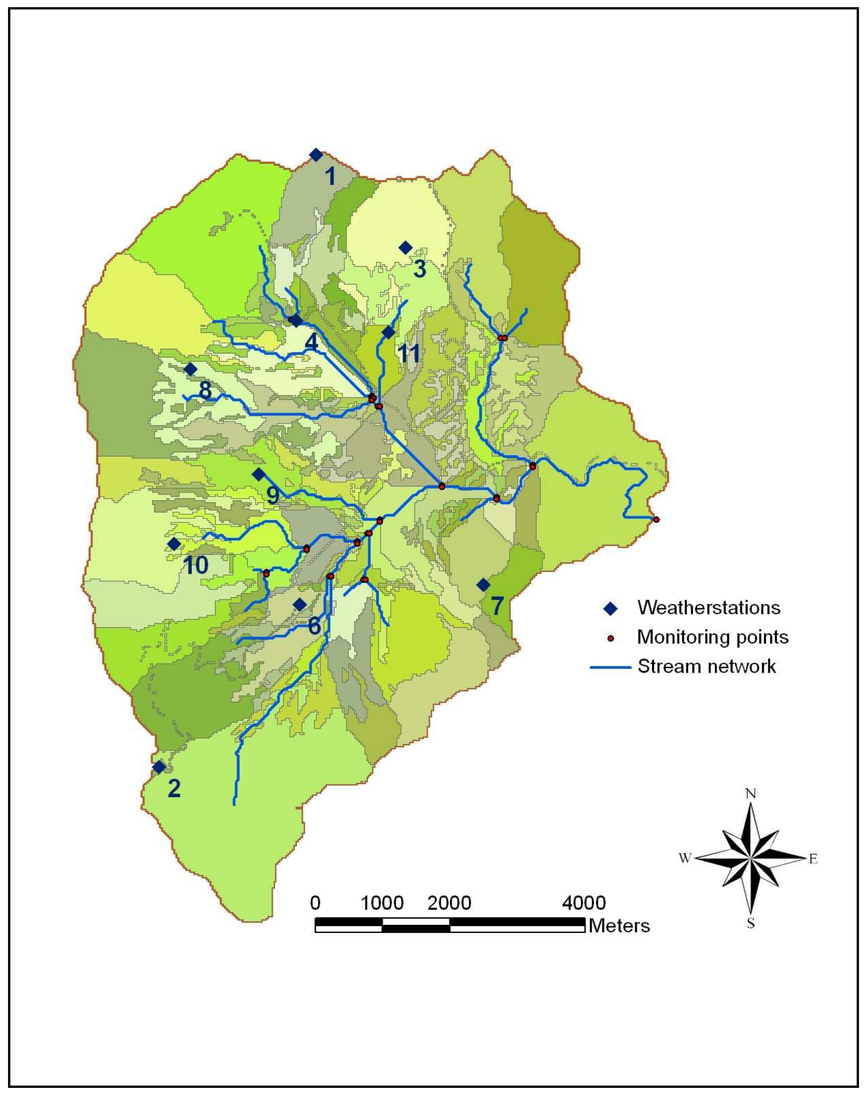

Figure 6 HRUs (Hydrological Reponse Units: Combination of Landuse, Soil type and Slope) of Haean catchment modeled with SWAT 2005)

Soil column experiments

Soil column experiments using the multistep outflow method allow to analyze water dynamics of soils and to determine soil hydrological parameters. This experiment will investigate the influence of soil additives (Polymers and Biochar) on water retention. Both PAM and Biochar are known for improving water holding capacity and decreasing of percolation rates especially for coarse sandy soil (Sivapalan, 2002). In the experiment different irrigation rates will be used according to the intensity of rain events. Flow paths will be analyzed using Brilliant Blue FCF. Obtained results will provide input data for inverse modeling.

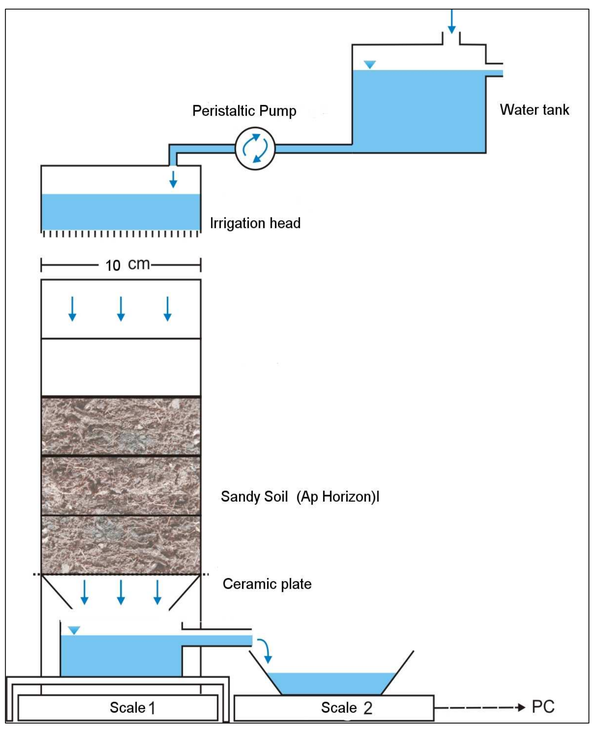

Figure 7 Soil column design (Leutner, B. 2008)

Field work in South Korea 2010

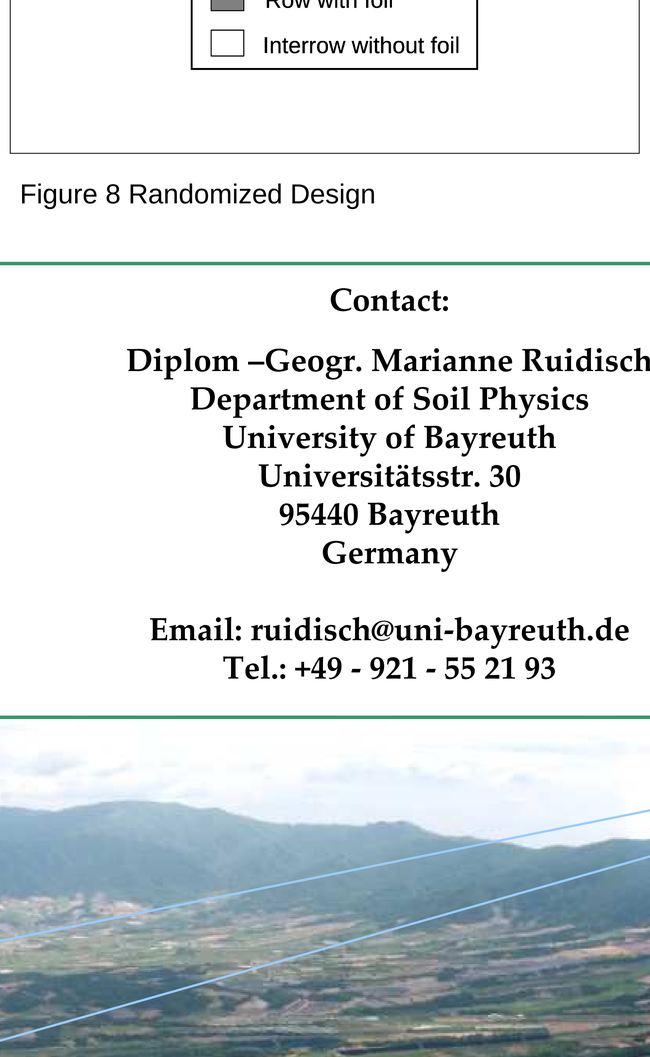

Figure 8 Randomized Design

Foil covering has an essential effect on flow patterns. This factor causes two main flow directions. The surface water is channeled laterally to the slope by topographical conditions of the agricultural fields. Subsurface water flow is controlled by slope directions.

Water retention and water content will be analyzed by installing tensiometers and TDR sensors in three different depths on agricultural field sites with a characteristic row planting system. Instruments will be distributed randomized (see Figure 8).

Additionally, flow paths will be analyzed by irrigation experiments using Brilliant Blue FCF. Soil column experiments will investigate flow paths in relation to soil additives whereas field irrigation experiments will investigate effects of row planting system on flow paths.

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Photo 5: Runoff-Plot (Plot 3) in 2009

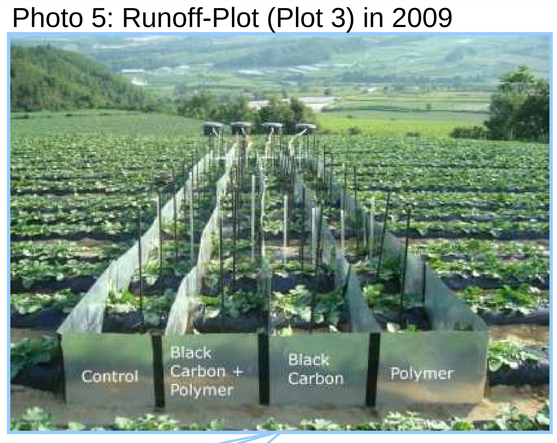

Photo 4 Haean Catchment, Province Yanggu/South Korea

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Sivapalan, S. (2003): Improving crop production by the use of PAM: Potential benefits to Australian agriculture, Australian Society of Agronomy