Report as of FY2006 for 2006KY68B: "Monitoring Soil Moisture for Efficient Use of Irrigated Water on Selected Grass Lawn"

Publications

- Conference Proceedings:
    - Koenig, Jason and Samuel Boateng, 2007, Monitoring Soil Moisture for Efficient Use of Irrigated Water on Selected Grass Lawns, in Proceedings of the Kentucky Water Resources Annual Symposium, Kentucky Water Resources Research Institute, Lexington, Kentucky, p 87-88.

Report Follows

Problem and Research Objectives

Soil moisture is the amount of water in the unsaturated zone that is available to growing plants. Soil moisture, at different locations in the unsaturated zone, varies with changes in the amount of precipitation (and/or irrigation) and the amount of evapotranspiration. Infiltration capacities of soils are considerably reduced with increased soil moisture. A reduction in infiltration capacity results in increased storm runoff. The adverse consequences of increased storm runoff include increased erosion, increased bed and suspended loads in streams, and increased non-point source pollution. Excess irrigation can cause a drastic increase in soil moisture with the consequent adverse effects of increased storm runoff. Recently, Kentucky Sanitation District 1 initiated a program to manage urban storm water in Northern Kentucky in compliance with USEPA regulations. The purpose of this project was to mitigate the adverse environmental and ecological effects of increased storm runoff related to irrigation. Efficient use of irrigated water on grass lawns has the potential to reduce excess soil moisture and decrease the potential for increased runoff during storm events. Thus, the study considered factors affecting infiltration to help in planning irrigation schedules to reduce excess soil moisture.

Effective monitoring of the soil moisture of irrigated fields has been shown to help in controlling the cost of irrigation and conserving valuable resources. This is achieved by using instruments such as tensiometers and neutron probes to monitor soil moisture. On an irrigated grass lawn, the ideal condition will be to maintain soil moisture between field capacity and wilting point. The objective of this study was to answer the following research questions:

1. What is the effect of soil texture on soil moisture changes during irrigation?
2. What is the effect of slope on the amount of moisture retained in the soil?
3. Can monitoring of soil moisture help in optimizing the use of irrigation water?

Methodology

Soil Texture Analysis

The goal of the soil texture analysis was to determine the percentage sand, silt, and clay at each lawn site. Each plot had a dimension of at least 5 m x 5 m. All sites were located on the Northern Kentucky University (NKU) Highland Heights campus. Soil texture was determined by particle size distribution analysis of the soil samples in the laboratory. Soil samples were taken from each site during the installation of the tensiometers (described below under soil moisture monitoring). The laboratory tests were performed in accordance with ASTM standard D422, Standard Test Method for Particle-Size Analysis of Soils. In general, the proportion of sand was the weight percentage retained on the .075 mm sieve, silt was the percent passing the 75 mm but larger than a diameter of 0.005 mm, and clay was the percent of particles smaller than 0.005 mm.

Slope Measurements

Three categories of slopes were used in selecting the grass lawns (a gentle to flat slope (0 to 10^o), a medium slope (10^o to 15^o), and a steep slope (more than 15^o). Two sites were selected to represent each category for a total of six sites. Originally, the slopes of the sites were to be measured by using a tape and a hand-held GPS, but the errors registered by the GPS device on the elevation values were too large for the data to be useful. Therefore, a Total Survey Station was used to measure the elevation using a local coordinate and a local elevation. The elevation and coordinates of about 25 data points were measured for each plot. The average distance between nearby points was about 1 meter. The data was processed by using the GIS software, ARCVIEW, to plot a contour of slope angles.

Soil Moisture Monitoring

Originally, two tensiometers were to be installed at depths of 15 cm (6 inches) and 30 cm (12 inches) at each of the three grass lawn sites. However, during the installation the insertion tool only could penetrate an average depth of 20 cm (8 inches). This resulted in the installation of the tensiometers at uniform depths of 20 cm. The tensiometers consist of a sealed, water-filled tube with a vacuum gage at the upper end and a porous ceramic tip that goes into the ground at the lower end. A compatible (in diameter) soil insertion tool was used to remove soil to the desired depth before installing the tensiometers. The soil removed was saved for the soil texture test as previously described. The installations were made so that the porous ceramic tips were in tight contact with the soil. As the soil dries, the soil-water tension increases and capillary forces in the soil pull water from the tube, creating a partial vacuum, which the gage at the above-ground end of the tube detects. When water is added to the soil around the tip through rainfall or applied irrigation, the soil-water tension is reduced and consequently the reading on the vacuum gage falls. The tensiometers could record a maximum of 0.85 atmospheres. Daily air temperature and precipitation amounts were gathered from NKU's Department of Physics and Geology weather center and the Northern Kentucky Airport Weather Station.

Readings were recorded at 6 pm every day instead of noon as originally proposed. This was done at the convenience of the NKU Grounds Department. Each day, NKU Grounds was provided with the tensiometer readings with advice to irrigate or not irrigate specific lawns. Irrigation of each lawn was resumed when the suction pressure became too high for the respective soil type. In heavy clay soils, irrigation did not resume until the suction pressures reached 70-80 centibars. However, in fine sandy soils, irrigation resumed when the pressures reached between 30 and 40 centibars. Generally, the finer the soil texture the higher the reading before the resumption of irrigation.

Findings and Significance

Slight variations in the composition of the soils at each site had just as much influence on the infiltration and runoff rates as did the slope. All other conditions being equal, lawns with gentle slopes tended to dry faster than steep slopes. This may be due to the high incidence angle of the sun on the gentle slopes. Lawns with even a small percentage more silt and clay tended to allow infiltration more slowly. Once such soils were wet, it took much longer for the water to evaporate and higher moisture contents were maintained for longer periods. Overall, the steep slope sites with high silt and clay content maintained higher moisture for longer periods once the site was wet. At air temperatures of about 27^{o} C (80^{o} F) and higher, all the grass lawns dried relatively quickly regardless of the soil composition and the slope. Because of moderate air temperatures during the fall and spring months, a regular irrigation schedule is not necessary and irrigation should be done on an as-needed basis. Irrigation during the summer months is necessary, and the frequency should be determined by the moisture content. An irrigation schedule which waters the lawns every other day or every third day would be an acceptable start to establishing a set schedule. As dry spells warrant, the frequency and intensity of irrigation need to be increased. Daily irrigation is only needed when air temperatures are continuously above 27^{o} C (80^{o} F).

Conservative estimates of an irrigation rate of 3 gallons per minute for an hour every day results in 180 gallons of water per lawn per day. An irrigation schedule based on soil moisture content will typically result in watering of the lawns every other day. Thus, about 90 gallons of water per lawn per day may be saved. At least 9000 gallons of water may be saved a day, given the areas of lawns on NKU’s Highland Heights campus. In addition, this may result in the reduction of stormwater runoffs during storm events.