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SENSOR-BASED TECHNOLOGIES FOR IMPROVING WATER AND NITROGEN USE EFFICIENCY

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Abstract. Limited reports exist on identifying the empirical relationships between plant nitrogen and water status with hyperspectral reflectance. This project is aiming to develop effective system for nitrogen and water management in wheat. Specifically: 1) To evaluate the effects of nitrogen rates and irrigation treatments on wheat plant growth and yield; 2) To develop methods to predict yield and grain protein content in varying nitrogen and water environments, and to determine the minimum nitrogen and water required to maintain wheat grain yield and quality; and 3) To develop models predicting yield loss due to nitrogen stress and yield loss due to water stress. Experiment was conducted at two experimental locations in south-west Idaho: at University of Idaho Parma Research & Extension Center and in a cooperating grower's field, Notus, ID in 2015. Irrigation treatments (3 irrigation levels) were the main plots, and treatments of nitrogen fertilization (4 nitrogen fertilization levels) were randomized within each main plot. The water was applied every 7 days utilizing the subsurface drip irrigation system. Dripper line was placed at 8 inch depth and spaced 28 inches apart. Three irrigation treatments of 50, 75, and 100 % of measured evapotranspiration were randomly assigned. Irrigation with the subsurface system was scheduled based on the estimated crop water use model by AgriMet. Crop physiological parameters were evaluated throughout the growing season: plant height was measured with a measuring ruler, crop reflectance was measured with GreenSeeker 505, chlorophyll content was estimated with SPAD, soil moisture was measured with ML3 Delta-T soil moisture sensor. Spring wheat grain yield responded differently to N and water application at two experimental sites. Significant differences in yield associated with N treatments were more pronounces at Parma (loam), compared to Notus (loamy sand). Lower soil organic matter (1.2%) coupled with sandy soil texture resulted in lower nutrient holding capacity, compared to Parma site (3.3% organic matter, loamy texture). For both locations, the optimum water treatment was 75% ET. Strong linear relationship was observed between the ET rate and soil VWC. Study will be repeated for two more growing seasons in Idaho and Montana.

Keywords. Crop sensors, water, nitrogen, wheat, irrigation, WUE, NUE

Sensor-Based Technologies for Improving Water and Nitrogen Use Efficiency

Growing concerns associated with water shortage and climate change emphasize the importance of nutrient management research, addressing water-related challenges relevant to semi-arid region. Cereal producers are under continuous pressure to improve yields and maintain quality, while addressing high input costs and environmental restrictions. Due to low rainfall, crop production in the southern Idaho is highly dependent on irrigation. Water and nitrogen fertilizer are both critical inputs to ensure successful plant growth and optimize yields. Accurate and timely information on water and nitrogen status obtained with remote sensors can be useful for irrigation and fertilization decision making. The crop physiological parameters such as leaf nitrogen content, chlorophyll, and canopy temperature as influenced by the different abiotic stressors can be measured by utilizing the remote sensing methodology at the canopy level.

Although wheat growth and yield responses to nitrogen fertilizer and water management have received extensive attention, to date, only limited reports exist on identifying the empirical relationships between plant nitrogen and water status with hyperspectral reflectance. This project is aiming to develop effective system for nitrogen and water management in wheat. Specifically: 1) To evaluate the effects of nitrogen rates and irrigation treatments on wheat plant growth and yield; 2) To develop methods to predict yield and grain protein content in varying nitrogen and water environments, and to determine the minimum nitrogen and water required to maintain wheat grain yield and quality; and 3) To develop models predicting yield loss due to nitrogen stress and yield loss due to water stress. Hard red spring wheat was planted at two experimental locations in south-west Idaho: at Parma Research & Extension Center and in a cooperating grower's field, Notus, ID, in April 2015. The experiments were laid out in a split-plot design with 4 replicates. Each plot size was 10 x 40 foot (two 14-row passes with the small plot research cereal seeder). Irrigation treatments (3 irrigation levels) were the main plots, and treatments of nitrogen fertilization (4 nitrogen fertilization levels) were randomized within each main plot. The water was applied every 7 days utilizing the subsurface drip irrigation system with flow meters that allow us to precisely measure the amount of applied water. Dripper line was placed at 8 inch depth and spaced 28 inches apart. Three irrigation treatments of 50, 75, and 100 % of measured evapotranspiration were randomly assigned. Irrigation with the subsurface system was scheduled based on the estimated crop water use model by AgriMet.

Crop physiological parameters were evaluated throughout the growing season: plant height was measured with a measuring ruler, crop reflectance was measured with GreenSeeker 505, chlorophyll content was estimated with SPAD, leaf area index was measured with AccuPAR LP-80, canopy temperature was measured with Infrared Thermometer (IRT); furthermore, soil moisture was measured with ML3 Delta-T soil moisture sensor. Spring wheat grain yield responded differently to N and water application at two experimental sites. Significant differences in yield associated with N treatments were much more pronounces at Parma (loam), compared to Notus (loamy sand). Lower soil organic matter (1.2%) coupled with sandy soil texture resulted in lower nutrient holding capacity, compared to Parma site (3.3% organic matter, loamy texture).

For both locations, the optimum water treatment was 75% ET. Strong linear relationship was observed between the ET rate and soil VWC. Averaged across the ET treatments, no significant differences associated with N rate were noted at any of the two sites. While comparable yields were obtained for all N rates at Notus, the incremental increase in yield was noted for Parma.

Relationship between NDVI and yield was more pronounced at Parma. NDVI was significantly affected by the ET treatments with 75% ET being optimum for maximizing biomass production. Very week relationship between SPAD and LAI and yield was observed for both sites, especially at less responsive Notus site. N rate has significantly affected biomass N content at both sites; biomass N content increased with increased N application rate.

In 2016 growing season, the study is repeated at two locations in Idaho, and expanded to Montana. Producer field days will be organized to showcase the research plots at each experimental site, each summer. Grower collaborators will conduct farmer-to-farmer extension by sharing their knowledge and experience. Outreach events for school/college students – will be focused on introducing the concepts of water and fertilizer use in agriculture and educating students on the importance of efficient resource management for sustainable crop production and continued food security.

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