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Abstract: Accurately predicting phenology in crop simulation models is critical for correctly simulating crop production. While extensive work in modeling phenology has focused on the temperature response function (resulting in robust phenology models), limited work on quantifying the phenological responses to varying water deficits has been done, particularly for the various versions of the EPIC-based plant growth component used in many agroecosystem models (e.g., EPIC, SWAT, WEPS, WEPP, GPFARM). Further, these EPIC-based plant growth components simulate few if any developmental events. The primary impetus for developing the Unified Plant Growth Model (UPGM) was to incorporate the various FORTRAN versions of the EPIC-based plant growth component into one model and to enhance various sub-models. The modified version of the EPIC-based plant growth component in the Wind Erosion Prediction System (WEPS) model was chosen as the platform used in building UPGM for many reasons including: 1) the WEPS adaptation of the EPIC crop growth component simulates plant growth dynamics in much greater detail (shoot number, shoot diameter, leaf mass, stem mass, reproductive mass, stem area index, and plant height), among other enhancements required for simulating plant effects on wind erosion; and 2) adding these changes into the other EPIC-based plant growth models would be more difficult than vice versa. New phenology, seedling emergence, and canopy height sub-models derived from the Phenology Modular Modeling System (PhenologyMMS V1.3) that respond to varying water deficits were incorporated into the standalone UPGM model. UPGM has been linked to the AgroEcoSystem-Watershed (AgES-W) model, which is a modular, Java-based spatially distributed model that implements hydrologic and water quality (H/WQ) simulation components under the Java Connection Framework (JCF) and the Object Modeling System (OMS) environmental modeling framework. The primary objective of this research study is to evaluate winter wheat phenological responses to varying water deficits using the UPGM component integrated within the AgES-W model. Existing data sets with up to 299 genotypes grown under variable irrigation practices in northeastern Colorado, USA will be used in the evaluation. Genotype data were assembled or generated through sequencing or other genotyping technology for all genotypes, including important genes/alleles influencing the phenology of different genotypes and maturity classes. Preliminary results suggest that spatial modeling of phenological responses to varying water deficits within 58 hydrologic response units (HRUs) on the Scott Field watershed near Ault, Colorado and plot data at Greeley, Colorado more accurately simulated winter wheat phenology than the standard model using only temperature.

***Keywords**:* Phenology; Water deficits; Model evaluation; Hydrologic and water quality modeling.