**DSSAT Overview**

The Decision Support System for Agro-technology Transfer (DSSAT) is a software application program that comprises crop simulation models for over 42 crops (as of Version 4.7.5) as well as tools to facilitate effective use of the models. The tools include database management programs for soil, weather, crop management and experimental data, utilities, and application programs. The crop simulation models simulate growth, development and yield as a function of the soil-plant-atmosphere dynamics.

DSSAT and its crop simulation models have been used for a wide range of applications at different spatial and temporal scales. This includes on-farm and precision management, regional assessments of the impact of climate variability and climate change, gene-based modeling and breeding selection, water use, greenhouse gas emissions, and long-term sustainability through the soil organic carbon and nitrogen balances. DSSAT has been in used by more than 16,500 researchers, educators, consultants, extension agents, growers, and policy and decision makers in over 174 countries worldwide.

The crop models require daily weather data, soil surface and profile information, and detailed crop management as input. Crop genetic information is defined in a crop species file that is provided by DSSAT and cultivar or variety information that should be provided by the user. Simulations are initiated either at planting or prior to planting through the simulation of a bare fallow period. These simulations are conducted at a daily step or in some cases, at an hourly time step depending on the process and the crop model. At the end of each day, the plant and soil water, nitrogen, phosphorus, and carbon balances are updated, as well as the crop’s vegetative and reproductive development stage.

For applications, DSSAT combines crop, soil, and weather data bases with crop models and application programs to simulate multi-year outcomes of crop management strategies. DSSAT integrates the effects of soil, crop phenotype, weather and management options, and allows users to ask “what if” questions by conducting virtual simulation experiments on a desktop computer in minutes which would consume a significant part of an agronomist’s career if conducted as real experiments.

DSSAT also provides for evaluation of crop model outputs with experimental data, thus allowing users to compare simulated outcomes with observed results. This is critical prior to any application of a crop model, especially if real-world decisions or recommendations are based on modeled results. Crop model evaluation is accomplished by inputting the user’s minimum data, running the model, and comparing outputs with observed data. By simulating probable outcomes of crop management strategies, DSSAT offers users information with which to rapidly appraise new crops, products, and practices for adoption.

With the release of DSSAT v4.7, many changes have been incorporated — from both the structure of the crop models and the interface to the models and associated analysis and utility programs. The DSSAT package provides models of 42 crops with new tools that facilitate the creation and management of experimental, soil, and weather data files. DSSAT v4.7 also includes improved application programs for seasonal, spatial, sequence and crop rotation analyses that assess the economic risks and environmental impacts associated with irrigation, fertilizer and nutrient management, climate variability, climate change, soil carbon sequestration, and precision management.

**Modules Overview**

Crop models calculate expected growth and development based on equations that describe how a crop, as community of plants, responds to soil and weather conditions. At their simplest level of interpretation, the equations used in a model are a set of differential equations representing rates of growth or development. Numerical integration over time, typically with daily or hourly time steps, allows estimation of growth, development, and water and nutrient levels. The equations are based on information from crop physiology, soil science, meteorology and other fields.

The models provided in DSSAT deal primarily with annual crops including wheat, rice, maize and various grain legumes but also include herbaceous perennials such as forage legumes and grasses. Besides crop growth and development, the models simulate water and nutrient dynamics in the soil and crop, so processes such as leaching, organic matter decomposition, and runoff are also considered. The level of process details varies greatly, and in many cases, users may select among model options, allowing the user to assess how different assumptions affect simulations.

Model applications range from real-time decision support for crop management to assessing the potential impact of climate change on global food security. Crop models are also invaluable as heuristic devices that help identify research problems where our current knowledge has limits and further research is needed. The ability of crop models to simulate how different weather years or soil conditions affect crop performance make models especially useful in research involving climatic uncertainty or geospatial variation. Recent advances in field phonemics and crop genomics are opening opportunities for crop models to support research in fundamental plant science.

Because the quality of simulation results depends heavily on the data inputs, DSSAT includes tools to assist modelers in organizing input data for crop management, soils and weather. An especially challenging set of inputs are the genotype-specific parameters (GSPs) used to quantify how one cultivar differs from another. GSPs are most often estimated through calibration to measurements from field trials, and DSSAT provides tools both to organize data used for calibration and to estimate required GSPs.

**DSSAT Model Application**

Crop models are used in a wide range of research. Below we provide brief descriptions by topics with links to more detailed examples or discussions.

Climate change impact assessment

DSSAT is widely used to simulate the potential impacts of climate change. Crop simulations have been a major data source for Intergovernmental Panel on Climate Change (IPCC) assessments for agriculture (Gitay et al., 2001; Easterling et al., 2007). As early as the second IPCC assessment report, extensive use was made of results from crop growth modeling (Reilly et al., 1996).

A more detailed discussion is here.

Irrigation management

The ability of DSSAT to simulate crop production under different levels of irrigation or other management conditions and for long-term (30-years or more) weather conditions, makes the model highly suitable for studying the impacts of irrigation management strategies. Of particular note are simulation options allowing for automatic irrigation applications (i.e., varying dates or amounts) when the available soil moisture is depleted to a user-specified threshold.

A more extensive treatment of these topics is given here.

Fertilizer management

Crop improvement

The ability of crop models to integrate effects of genetics (G), environment (E) and management (M) makes them attractive tools to support crop improvement.

A more detailed discussion is here.

Gene-based modeling

With the rapidly increasing availability of data on DNA sequences of individual cultivars or breeding lines, there is growing interest in using this incredible data resource to improve crop model development and applications. Similarly, advances in understanding of the control of plant processes at the molecular level suggest opportunities to strengthen how mechanisms are represented in crop models. These interests have given rise to a broad area of activities termed “gene-based modeling.” Topics of interest to DSSAT users and system modelers can pertain to four activities:

Estimation of genotype-specific model parameters (GSPs)

Improved representation of crop processes

Guiding genetic dissection of crop processes through analysis of GSPs as phenotypes

Use of genetic data for genetically realistic sensitivity analyses

A more extensive treatment of these topics is given here.

Pest and disease management

Spatial analysis

Tillage simulation

Crop rotations