CROP SIMULATION MODELS

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Model: A model is a simplified representation of a system or a process.

Modelling is based on the assumption that any given process can be expressed in a formal mathematical statement or set of statements.

Simulation is the process of building models and analyzing the system.

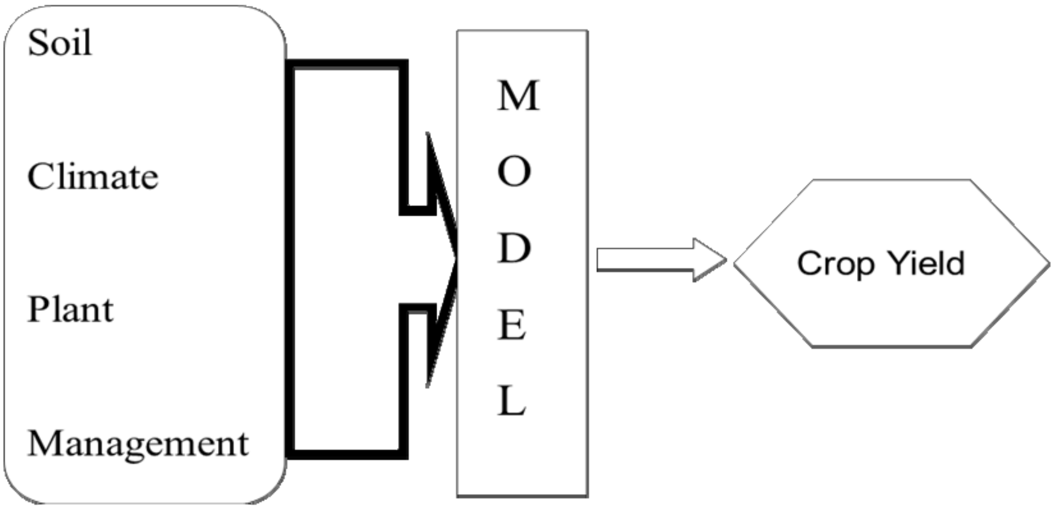
Crop model: Simple representation of a crop.

Crop models are tools of systems research which help in solving problems related to crop production.

Why we need simulation models?

- To assimilate knowledge gained from field experimentation
- To provide a structure that promotes interdisciplinary collaboration
- To promote the use of systems analysis for solving problems
- To offer dynamic, quantitative tools for analyzing the complexity of cropping systems

Crop models require certain input data which is used by the model to further generate the required output.



Input data requirement:

Crop modeling requires data related to weather, crop, soil, management practices and insect-pests.

Weather data includes: Maximum and minimum temperature, rainfall, relative humidity, solar radiation and wind speed. Weather data is required at daily time step to assess daily crop growth processes.

Crop data includes: Crop name, variety name, crop phenology (days to anthesis, days to maturity etc.), leaf area index, grain yield above ground biomass, 1000 grain weight.

Soil data includes: Thickness of soil layer, pH, EC, N, P, K, soil organic carbon, soil texture, sand and clay percent, soil moisture, saturation, field capacity and wilting point of soil, bulk density.

Crop management data includes: Date of sowing of crop is required to initiate the simulation process. Generally sowing date is taken as the start time for the simulation. In case of transplanted rice date of transplanting is used instead of sowing date. Seed rate and depth of seeding are also required. Use of inputs in the crop field, namely, irrigation, fertilizer, manure, crop residue etc. needs to be mentioned. Amount of these inputs are specified along with their type, date of application and depth of placement. If crop residues or organic nutrient sources are applied in the field then C:N ratio of those sources are quantified.

Pest data includes: Name and type of the pest, their mode of attack, pest population at different crop growth stages. Data on insects or pests are included only in those models which contains the pest module.

Steps in modelling

- Define goals: Agricultural system is complex comprising of various disciplines. In order to develop or understand a crop model one requires strong knowledge base of different subjects. Depending upon the objective of study, knowledge base of different disciplines is integrated to develop a crop model.
- Define system and its boundaries: In agriculture, crop field is chosen as a system.
- Define key variables in system: Variables include state, rate, driving and auxillary variables. State variables are those which can be measured or quantified, e.g. soil moisture content, crop yield etc. Rate variables are the rates of different processes operating in a system, e.g. phosynthesis rate, transpiration rate. Driving variables are the variables which are not part of the system but the affect the system, e.g. sunshine, rainfall. Auxillary variables are the intermediated products, e.g. dry matter partitioning, water stress etc. These variables are identified in the crop field. After identification of these variables relationship among different variables is determined and a relational diagramme is drawn (Fig. 1). This helps in better understanding of the whole process.
- Quantify relationships: Once the relationship is established it is then quantifies using different mathematical equations and functions.
- Calibration/Validation: When the model is developed, it requires calibration and validation. First the model is run with any experimental data set and calibrated accordingly. Calibrated model is then validated with another experimental dataset to check its simulation ability under different situations or environment.
- Sensitivity analysis: Validated model is then tested for its sensitivity to different factors (e.g. temperature, rainfall, N dose). This is done to check whether the model is responding to changes in those factors or not.
- Simplification: Any model is initially written in computer programming languages. But they are made simple by making it user friendly.
- Use of models in decision support: Once developed, calibrated and validated any model can be used in any decision support system for forecasting or making suitable decisions regarding crop management.

Possible applications of crop model:

- Estimation of potential yields
- Estimation of yield gaps: principal causes and their contribution
- Yield forecasting
- Impact assessment of climatic variability and climatic change
- Optimizing management- Dates of planting, variety, irrigation and nitrogen fertilizer
- Environmental impact- percolation, N losses, GHG emissions, SOC dynamics
- Plant type design and evaluation
- Genotype by environment interactions

Limitations of modeling

- Input data: Models require large amount of input data, which may not be available with the user.
- Skilled manpower:
- Knowledge of computers & computer language
- Limited awareness and acceptance towards modeling
- Multidisciplinary knowledge
- No model can take into account all the existing complexity of biological systems. Hence simulation results have errors
- A model is a tool for improving critical thought, not a substitute for it
- Models can help formulate hypotheses and improve efficiency of field experiments, but they do not eliminate the need for continued experimentation.
- Models developed for a specific region cannot be used as such in another region. Proper parameterization and calibration is needed before using a model.

Conclusions

- Models are holistic, knowledge-based global tools for global and local applications
- Help us in assimilating knowledge gained from experimentation
- Help understand/predict behavior of biological systems on the basis of underlying level of integration
- Offer dynamic, quantitative tools for analyzing the complexity of agricultural systems
- Promote inter-disciplinary research
- Increase the efficiency of agricultural research and management
- Improve agronomic efficiency and environmental quality

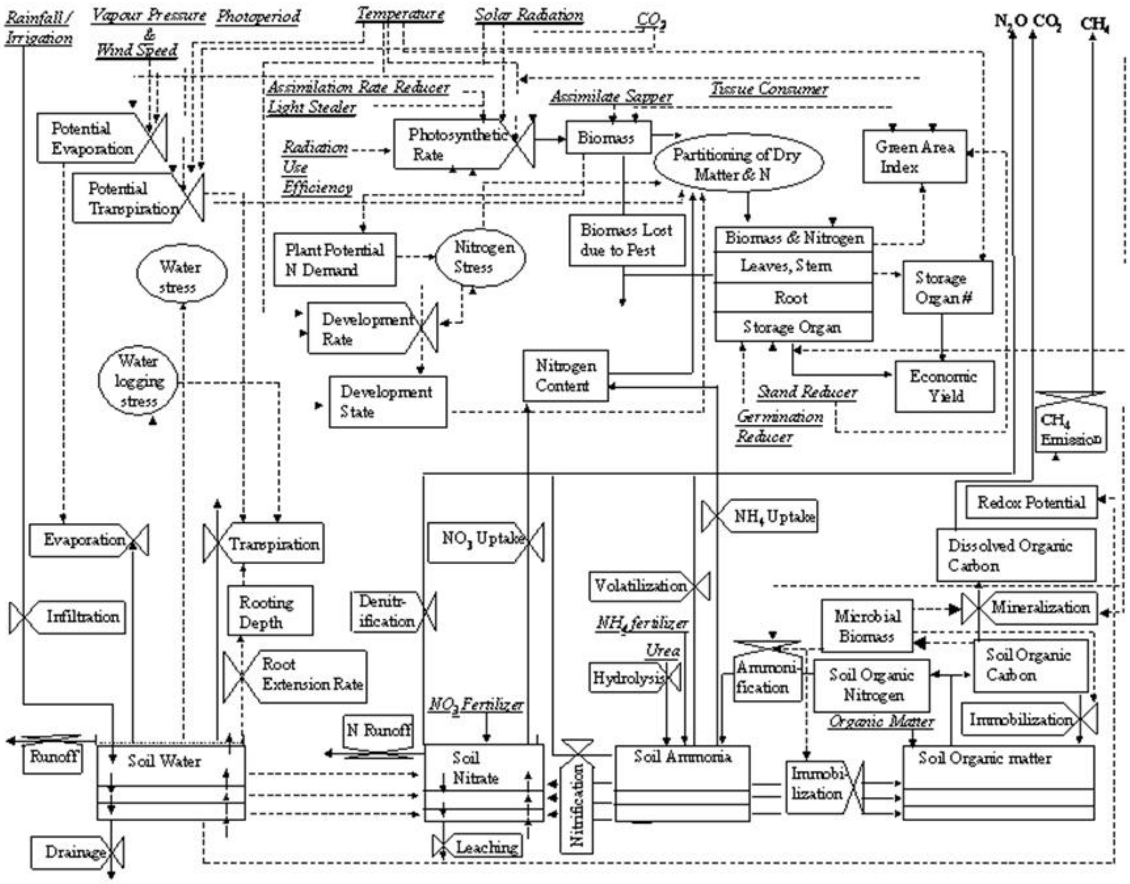


Fig. 1 Relational diagramme of InfoCrop model