A Survey on Crop Model Applications in Thailand under GRENE

APAN Meeting,

Chiang Mai, 16 Feb 2012

HONDA Kiyoshi *1, Daroowan Kamthonkiat *2,
Sujittra Charoenhirunyingyos *3, Chudech Losiri *4,
Rassarin Chinnachodteeranun *4
*1 Chubu U., *2 Thammasat U., *3 Kasetsart U., *4 Asian Institute of Technology

Objectives of the Survey

- To identify appropriate crop models for impact assessment system of climate change on crop productivity/suitability under GRENE project

Requirement of the models

- Being able to simulate the impact of climate change
  - Input parameters should have major weather data
    - Temperature, Rainfall, Solar Rad…..
  - Output parameter should have yield estimation
- Physiological or statistical model
- Popular and practically used in Thailand
  - The evaluation system to be practically utilized.
  - Model parameters for local popular varieties

Outline of the survey

- Crop modeling survey in Thailand
  - **rice, cassava and sugarcane**
  - Corn (Maize), Rubber, Spinach
- Collection of literature on crop models (reports, papers and etc.)
- Interviews to experts/users: universities, research institutes, local agriculture offices and/or advanced farmers

Crop Growth Models Applied in Thailand

- **RICE**
  - **DSSAT–CERES-Rice**
  - **SWAP-WOFOST**
  - **ORYZA 2000**
  - **H08**
  - **CATCHCROP**
- **Sugarcane**
  - **DSSAT-Canegro**
- **Cassava**
  - **DSSAT-GUMCAS**

DSSAT

Decision Support Systems for Agrotechnology Transfer

- Developed by the International Benchmark Site Network for Agrotechnology Transfer (IBSNAT) project.
- Simulates crop growth and its development over time.
- Simulates soil water, carbon and nitrogen processes and management practices.
- A framework and plant modules
  - Support quick analysis/optimization of alternative options for decision makers.
  - Includes several plant modules e.g. rice, wheat, maize, potato..

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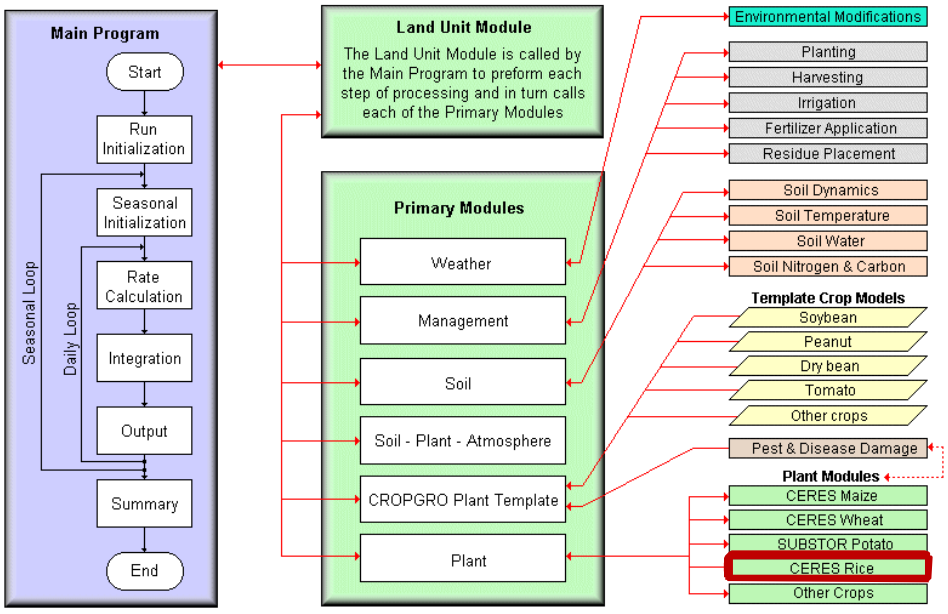

Overview of the components and modular structure of the DSSAT cropping system model

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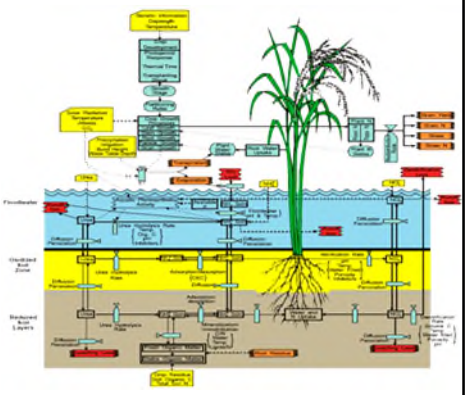
Crop Environmental Resource Synthesis (CERES) Rice

- A plant module in DSSAT
- Estimate rice yield under different crop conditions: rainfed, irrigation and rice varieties.
- Simulate crop water use under difference environments
- Ability to simulate nitrogen transformation under different crop conditions.



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Input and Output of DSSAT CERES-Rice Model

Input	Process	Output
Controllable Inputs		
Variety seed	Plant growth	Grain yield
Plant spacing	Physical development	Yield components
Date of sowing	Morphological development	Above of phasic
Date & amount of irrigation	Soil water balance	Development changes
Date & amount of N fertilization	Soil nitrogen balance	Optimal output at user selected frequency
Type of fertilizer N		Soil water balance components
Genetic coefficients		Root densities
Type of residues		Indices of nitrogen & nitrogen & water stress
Non-controllable Inputs		
Daily weather data		
Day length		
Soil properties & initial conditions		

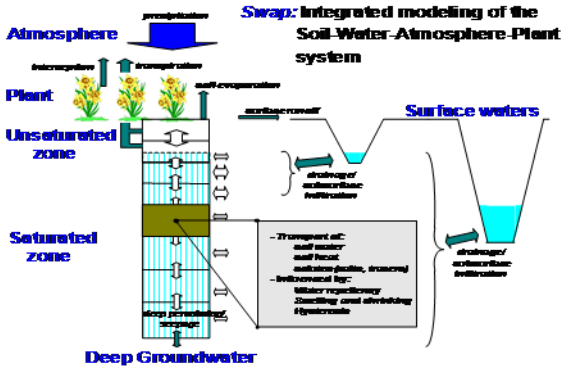
Source: Ritchie et al. (1986)

Evaluation of the DSSAT-CERES-Rice

Model	DSSAT-CERES-Rice
Developer (s), Year	Ritchie (1986), IBSNAT
No. of Papers	7
Scale	Farm-Provincial
Type of Model	A physiological rice model
Framework	DSSAT
Ability to evaluate climate	Yes (minimum temperature, maximum temperature), rainfall, solar radiation , maximum relative humidity , wind speed)
Stage of application	Research, practical application
Parameter availability	
Model User	Researcher, Rice research center, University, Department of Land Development, Department of Agriculture
Overall evaluation	Practically used

Soil Atmosphere Plant System (SWAP)

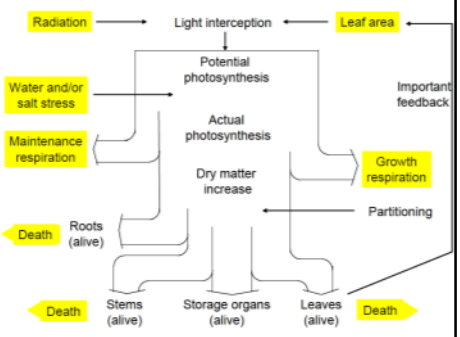
- Physiological model
- Simulate transpiration, soil evaporation, root zone soil moisture
- crop yield under the different climatic conditions.
- WOFOST crop model



A schematized overview of the modeled system
Source: Van Dan et al. (1997)

SWAP-WOFOST

- Simulate the growth and production of annual field crops on the scale of a single farm field
- Processes simulated for crop growth;
  - phenological development
  - CO2 assimilation
  - transpiration
  - respiration
  - dry matter accumulation.
  - partitioning of assimilates to the various organs



SWAP-WOFOST Model input/Output

- Input
  - Daily climate data (min-max temp, rain, solar, wind, vapor pressure..)
  - Soil properties
  - crop-specific growth parameters
  - Watertable, irrigation
- Output
  - Crop growth status and yield
  - Water balance, soil moisture, water balance
  - Required irrigation

Evaluation of the SWAP-WOFOST Rice Model

Model	SWAP-WOFOST
Developer (s), Year	van Keulen & Wolf (1986), van Diepen et al. (1988) Version 7.0 (Boogaard et al. 1998) Wageningen Agricultural University
No. of Papers	3
Scale	Farm-Provincial
Type of Model	A physiological rice model
Framework	SWAP
Ability to evaluate climate	Yes (maximum temperature, minimum temperature, global radiation, wind speed, vapor pressure, evapotranspiration and rainfall)
Stage of application	Research, practical application
Parameter availability	
Model User	Researcher, University, Department of Meteorology
Overall evaluation	Practically used

ORYZA2000

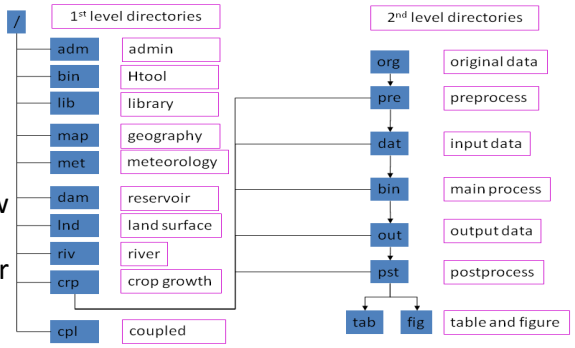
- A model to study the impact of climate change to rice yields, and to explore adaptive management options (fertilizer, cultivar type, irrigation strategy, sowing date, etc.).
- Developed by IRRI, Wageningen University
- ORYZA1 for potential production, ORYZA-W for water-limited production, and ORYZA-N for nitrogen-limited production.
- The model combines several modules: aboveground crop growth, evapotranspiration, nitrogen dynamics, soil-water balance, and others.

Evaluation of the ORYZA2000

Model	ORYZA2000
Developer (s), Year	The International Rice Research Institute (IRRI) and Wageningen University and Research Center (WUR) developed ORYZA1 (Mid-90s) → ORYZA2000 (2001)
No. of Papers	1
Scale	Farm-Provincial
Type of Model	A physiological rice model
Framework	-
Ability to evaluate climate	Yes (solar radiations, temperature (min. and max.) vapour pressure, wing velocity and) precipitation
Stage of application	Review, partially practical
Parameter availability	
Model User	Research in University
Overall evaluation	Partially used

H08

- A global water resources model developed by Hanasaki et al.
- Coming to Thailand under "Integrated Study Project on Hydro-Meteorological Prediction and Adaptation to Climate Change in Thailand" (IMPAC-T).
- Six modules:
  - land surface hydrology
  - river routing
  - crop growth
  - reservoir operation
  - environmental flow requirement
  - anthropogenic water withdrawal



Evaluation of the H08 Rice Model

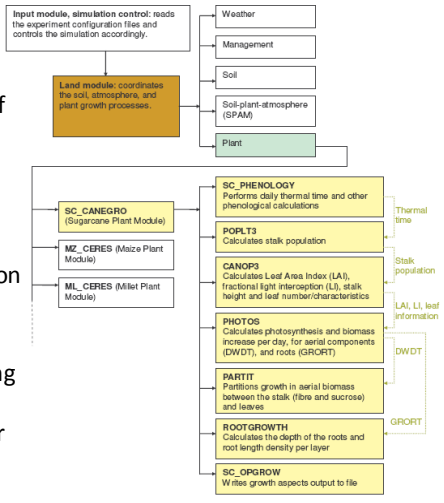
Model	H08
Developer (s), Year	Hanasaki et al. (2008) The National Institute for Environmental Studies (NIES), University of Tokyo, Tokyo Institute of Technology
No. of Papers	1
Scale	Provincial
Type of Model	A physiological model
Framework	
Ability to evaluate climate	Yes (surface pressure, rainfall rate, snow fall rate, wind speed, long wave downward radiation, specific humidity, short wave downward radiation, and air temperature)
Stage of application	Research
Parameter availability	
Model User	Royal Irrigation Department, Meteorological Department
Overall evaluation	Partially used

Evaluation of the CATCHCROP Rice Model

Model	CATCHCROP
Developer (s), Year	Perez et al. (2002)
No. of Papers	1
Scale	Farm-Provincial
Type of Model	A physiological model
Framework	
Ability to evaluate climate	Yes (average potential evapotranspiration, number of rainy days, mean daily rainfall (mm), total rainfall)
Stage of application	Research
Parameter availability	
Model User	Department of Livestock Development
Overall evaluation	Partially used

DSSAT-Canegro Sugarcane Model

- Simulates sugarcane crop growth and development from daily weather data, cultivar and soil properties, and management input data.
- It simulates:
  - Canopy development at the tiller and leaf level
  - Radiation capturing from leaf area index
  - The water balance using soil-plant-atmosphere continuum principles
  - Biomass accumulation following a radiation efficiency/respiration
  - Biomass partitioning to different plant components, including stalk sucrose, using a source sink approach and affected by physiological age, temperature and water stress.

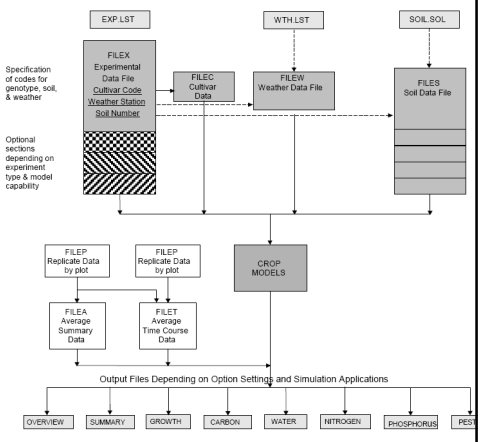


Evaluation of the DSSAT-CANEGRO Sugarcane Model

Model	DSSAT-CANEGRO
Developer (s), Year	Inman-Bamber (1991) and Singels and Bezuidenhout (2002), IBSNAT
No. of Papers	4
Scale	Farm-Provincial
Type of Model	A physiological sugarcane model
Framework	DSSAT
Ability to evaluate climate	Yes (minimum temperature, maximum temperature), rainfall, solar Radiation , maximum relative humidity , wind speed)
Stage of application	Research, practical application
Parameter availability	
Model User	Researcher, Rice research center, University, Department of Land Development, Department of Agriculture
Overall evaluation	Practically used

DSSAT-GUMCAS Cassava model

- The DSSAT-GUMCAS model describes the daily growth of cassava
- The application of the model under DSSAT need four categories of input data i.e. soil data, weather data, management data, and genetic coefficients of each cassava cultivar.
- The rate of vegetative development is influenced by temperature and moisture conditions, while the rate of reproduction develop is influenced by both of these factors as well as by photoperiod



Evaluation of the DSSAT-GUMCAS Cassava Model

Model	GUMCAS
Developer (s), Year	Mathews and Hunt (1994), IBSNAT
No. of Papers	2
Scale	Farm-Provincial
Type of Model	A physiologically based cassava model
Framework	DSSAT
Ability to evaluate climate	Yes (minimum temperature, maximum temperature), rainfall, solar Radiation , maximum relative humidity , wind speed)
Stage of application	Research, practical application
Parameter availability	
Model User	Researcher, Rice research center, University, Department of Land Development, Department of Agriculture
Overall evaluation	Practically used

Climate Parameters for Models

Climate parameter	DSSAT	SWAP WOFOST	ORYZA 2000	H08	CATCHCROP
Min-Max temp	√	√	√	√	-
Daily Rainfall	√	√	√	√	√ (+No.rainday, total RF)
Evapotranspiration	-	√	-	-	√
Solar Radiation	√	√	√	√	-
Humidity	√	-	-	√	-
Wind speed	√	√	√	√	-
Vapor pressure	-	√	√		-
Surface pressure	-	-	-	√	-
Snow fall	-	-	-	√	-
Short & long wave downward	-	-	-	√	-

Crop	No. of Model (s)	Mostly used model in Thailand	Reasons to recommend DSSAT
Rice	5	DSSAT-CERES-Rice	• Widespread experience with its calibration and data requirements • LDD soil data is linked •DSSAT has a graphical user interface, which enables the user to input data, run the crop models and graphically view the results of the simulation. • makes it possible to estimate yields on a field or provincial scale with satisfactory accurate under different climate scenarios. • DSSAT shows high capability for crop and N-fertilizer studying.
Cassava	1	DSSAT-GUMCAS	
Sugarcane	1	DSSAT- CANEGRO	

****** DSSAT was the mostly used system in Thailand, the comments then go to DSSAT.***

Developed Genetic Coefficient Parameters of Crop Variety in Thailand for DSSAT

Crop	Crop variety -Thailand
Rice	7 : KDML105, NIEN Sanpatong, Supanburi60, Chainat1, DOA1, RD23, HPR90
Cassava	6 : RY05, RY90, RY72, RY07, RY09, KU50
Sugarcane	2 : U-Thong2, K84-200

*** Based on the literature review of DSSAT– cases study in Thailand.*

Conclusion

- DSSAT is the most popular model and has been applied to rice, sugarcane, cassava .
  - Validation/application history especially for rice and sugarcane
  - Cultivar data of Thai local species
  - Linking national soil map to DSSAT
  - Existence of training hub (Chiang Mai U.)
- More survey for maize, rubber plantation
- Scenario Simulation System (under development)
  - Expansion of our Data Assimilation System
  - Obtaining Daily Data through Interpolation and disaggregation (past and future scenario)
  - WB, IRI, NOAA
  - Impact of climate change(yield, water requirement)
  - adaptation(planting date, alt. variety)