Crop Growth Modeling And Its Applications In Agricultural

Learn to create and use simulation models—the most reliable and cost-effective tools for predicting real-world results! The Handbook of Processes and Modeling in the Soil-Plant System is the first book to present a holistic view of the processes within the soil-plant-atmosphere continuum. Unlike other publications, which tend to be more specialized, this book covers nearly all of the processes in the soil-plant system, including the fundamental processes of soil formation, degradation, and the dynamics of water and matter. It also illustrates how simulation modeling can be used to understand and forecast multiple interactions among various processes and predict their environmental impact. This unique volume assembles information that until now was scattered among journals, bulletins, reports, and symposia proceedings to present models that simulate almost all of the processes occurring in the soil-plant system and explores the results that these models are capable of producing. With chapters authored by experts with years of research and teaching experience, the Handbook of Processes and Modeling in the Soil-Plant System examines: physical, chemical, and biological soil processes the soil formation and weathering process and its modeling the impact of radioactive fallout on the soil-plant system soil degradation processes and ways to control them water and matter dynamics in the soil-plant system growth and development of crops at various levels of production the potentials and limitations of using simulation models Students, educators, and professionals alike will find the Handbook of Processes and Modeling in the Soil-Plant System an invaluable reference on the soil-plant-atmosphere system and an ideal tool to help develop an effective decision support system.

The use of crop-soil modelling has so far been mainly confined to the research community. Practical applications have occurred in the areas of decision tools for irrigation studies and pest management. However, there is potential to increase its applied use.This book reviews progress in crop-soil simulation modelling and assesses its application to agriculture in developing countries. It is based on work sponsored by the Natural Resources Systems Programme of the UK Department for International Development.

Learning mathematical modeling need not be difficult. Unlike other books, this book not only lists the equations one-by-one, but explains in detail how they are each derived, used, and finally assembled into a computer program for model simulations. This book shows how mathematics is applied in agriculture, in particular to modeling the growth and yield of a generic crop. Topics covered are agriculture meteorology, solar radiation interception and absorption, evapotranspiration, energy and soil water balance, soil water flow, photosynthesis, respiration, and crop growth development. Rather than covering many modeling approaches but in superficial detail, this book selects one or two widely-used modeling approaches and discusses about them in depth. Principles learned from this book equips readers when they encounter other modeling approaches or when they develop their own crop models.

This paper describes the use of the CliCrop model in the context of climate change general assessment modeling. The MIT Integrated Global System Model (IGSM) framework is a global integrated assessment modeling framework that uses emission predictions and economic outputs from the MIT Emission Prediction and Policy Analysis (EPPA) model and earth system modeling predictions from the IGSM to drive a land system component, a crop model (CliCrop) and a Water Resource System (WRS) model. The global Agriculture and Water System are dependant upon and interlinked with the global climate system. As irrigated agriculture provides 60% of grains and 40% of all crop production on 20% of global crop lands and accounts for 80% of global water consumption, it is crucial that the agricultural-water linkage be properly modeled. Crop models are used to predict future yields, irrigation demand and to understand the effect of crop and soil type on food productivity and soil fertility. In the context of an integrated global assessment, a crop water-stress and irrigation demand model must meet certain specifications that are different for other crop models; it needs to be global, fast and generic with a minimal set of inputs. This paper describes how CliCrop models the physical and biological processes of crop growth and yield production and its use within the MIT Integrated Global System Model (IGSM) framework, including the data inputs. This paper discusses the global data bases used as input to CliCrop and provides a comparison of the accuracy of CliCrop with the detailed biological-based crop model DSSAT as well as with measured crop yields over the U.S. at the country level using reanalyzed weather data. In both cases CliCrop performed well and the analysis validated its use for climate change impact assessment. We then show why correctly modeling the soil is important for irrigation demand calculation, especially in temperate areas. Finally, we discuss a method to estimate actual water withdrawal from modeled physical crop requirements using U.S. historical data.

During the past several years, the NASA Program in Controlled Ecological Life Support Systems (CELSS) has continued apace with crop research and logistic, technological, and scientific strides. These include the CELSS Test Facility planned for the space station and its prototype Engineering Development Unit, soon to be active at Ames Research Center (as well as the advanced crop growth research chamber at Ames); the large environmental growth chambers and the planned human test bed facility at Johnson Space Center; the NSCORT at Purdue with new candidate crops and diverse research into the CELSS components; the gas exchange data for soy, potatoes, and wheat from Kennedy Space Center (KSC); and the high-precision gas exchange data for wheat from Utah State University (USU). All these developments, taken together, speak to the need for crop modeling as a means to connect the findings of the crop physiologists with the engineers designing the system. A need also exists for crop modeling to analyze and predict the gas exchange data from the various locations to maximize the scientific yield from the experiments. One fruitful approach employs what has been called the 'energy cascade'. Useful as a basis for CELSS crop growth experimental design, the energy cascade as a generic modeling approach for CELSS crops is a featured accomplishment in this report. The energy cascade is a major tool for linking CELSS crop experiments to the system design. The energy cascade presented here can help collaborations between modelers and crop experimenters to develop the most fruitful experiments for pushing the limits of crop productivity. Furthermore, crop models using the energy cascade provide a natural means to compare, feature for feature, the crop growth components between different CELSS experiments, for example, at Utah State University and Kennedy Space Center. Volk, Tyler Unspecified Center NCC2-608...

Most books covering the use of computer models in agricultural management systems target only one or two types of models. There are few texts available that cover the subject of systems modeling comprehensively and that deal with various approaches, applications, evaluations, and uses for technology transfer. Agricultural System Models in Field Res

New policies must be adopted under climate change conditions to secure sustainability of agricultural crop production. Despite the proved reliability of present climate and crop-growth modelling tools for climate risk assessments, they have been not been noticeably applied for supporting agricultural decision-making in practice. The EU proposal AGRIDEMA provided initial contacts and collaborations between "developers" and potential "users", basically researchers and experts at agricultural services. This book reviews the AGRIDEMA results. The book is designed to introduce the currently-available climate and crop-growth models, to summarise their potentialities as tools to provide reliable Climate-Change adaptation options in agriculture and to show several examples of the combined use such tools in specific climate-change agricultural risks in several countries.

This book presents a generic process-based crop growth model, GECROS (Genotype-by-Environment interaction on CROp growth Simulator), recently developed in Wageningen. The model uses robust yet simple algorithms to summarize the current knowledge of individual physiological processes and their interactions and feedback mechanisms. It was structured from the basics of whole-crop systems dynamics to embody the physiological causes rather than descriptive algorithms of the emergent consequences.It also attempts to model each process at a consistent level of detail, so that no area is overemphasized and similarly no area is treated in a trivial manner. Main attention has been paid to interactive aspects in crop growth such as photosynthesis-transpiration coupling via stomatal conductance, carbon-nitrogen interaction on leaf area index, functional balance between shoot and root activities, and interplay between source supply and sink demand on reserve formation and remobilization. GECROS combines robust model algorithm, high computational efficiency, and accurate model output with minimum number of input parameters that require periodical destructive sampling to estimate.

Potato is the fourth major staple food in the world and is still rapidly gaining importance, especially in the tropics. In May, 1994 the second international potato modelling conference was held in Wageningen, the Netherlands, as a summerschool of the C. T. de Wit Graduate School. The conference was sponsored by DLO, SCRI, SSCR, W AU and the LEB-Fund. Over 80 scientists participated, coming from 16 countries. Of each crop physiological and modelling subject, a leading scientist was requested to write a review of the most recent developments in his or her field. The reviews, with highlights from the authors' own work, are such that the physiological work described is of interest to the modeller and the modelling work to the crop physiologist. Applications of the quantitative approach are also reviewed in the concluding chapters that deal with decision support systems, breeding and agro-ecological zoning. An outstanding point of this book is that both the crop ecology and the modelling of a broad range of biotic and abiotic factors are treated by scientists representing groups which are specialized in the subject. The two related disciplines met during the conference and thus wrote the chapters with each other's interest in mind. The book highlights the limitations for potato growth and development from the viewpoints of both the crop physiologist and the crop-systems analyst.

Model studies focus experimental investigations to improve our understanding and performance of systems. Concentrating on crop modelling, this book provides an introduction to the concepts of crop development, growth, and yield, with step-by-step outlines to each topic, suggested exercises and simple equations. A valuable text for students and researchers of crop development alike, this book is written in five parts that allow the reader to develop a solid foundation and coverage of production models including water- and nitrogen-limited systems.

Crop model intercomparison and improvement are required to advance understanding of the impact of future climate change on crop growth and yield. The initial efforts undertaken in the Agriculture Model Intercomparison and Improvement Project (AgMIP) led to several observations where crop models were not adequately simulating growth and development. These studies revealed where enhanced efforts should be undertaken in experimental data to quantify the carbon dioxide × temperature × water interactions in plant growth and yield. International leaders in this area held a symposium at the 2013 ASA, CSSA, and SSSA Annual Meeting to discuss this topic. This volume in the Advances in Agricultural Systems Modeling series presents experimental observations across crops and simulation modeling outcomes and addresses future challenges in improving crop simulation models. IN PRESS! This book is being published according to the “Just Published” model, with more chapters to be published online as they are completed.

Crop modelling has huge potential to improve decision making in farming. This collection reviews advances in next-generation models focused on user needs at the whole farm system and landscape scale.

Part I - Current plant growth models, applications, and data: Mathematical descriptions of plant growth and development; Applied plant growth models for grazinglands, forests and crops; Data for plant growth modeling, and evaluation. Parte II - Forescasting and estimating plant yield: Choosing a basis for yield forecasts and estimates; Forecasting andestimating effects of weather on yield; The scale problem, modeling plant yield over time and space. Part III - The future of applied plant growth modeling: The future of applied plant growth modeling.

Achieving food security and economic developmental objectives in the face of climate change and rapid population growth requires systems modelling approaches, for example in the design of sustainable agriculture farming systems. Such approaches increase our understanding of system responses to different soil and climatic conditions, and provide insights into the effects of various variable climate change scenarios, providing valuable information for decision-makers. Further, in the agricultural sector, systems modelling can help optimise crop management and adaptation measures to boost productivity under variable climatic conditions. Presenting key outcomes from crop models used in agricultural systems this book is a valuable resource for professionals interested in using modelling approaches to manage the growth and improve the quality of various crops.

This memoir is the eighth in a series related to Mathematical Models of Crop Growth and Yield. The series focuses on ideas which have been found useful in describing crop response to applied nutrients (N, P, and K) and accumulation of biomass and mineral elements with calendar time. No attempt has been made to survey the broad field of crop modeling. Results have evolved out of work with farmers and engineers over a period of nearly forty years. There has been extensive collaboration with other scientists in Florida as well as other regions within the USA. Analysis has been drawn from the large array of data from research conducted around the world over 150 years. While basic concepts from physics, chemistry, and biology have been incorporated, the models have been developed at the field scale for the sake of application. Methods of applied malthematics and statistics have been utilized to provide a more rigorous foundation to the models. Procedures from regression and analysis of variance have been borrowed from statistics. In fact this is the focus of the present memoir. As often occurs in research, the question is how to analyze a complex set of data. For example, response of biomass and mineral uptake to applied nutrients (N, P, and K) where some other management factor (such as intercropping) is varied as well. Is it appropriate to average over the response variables? Are there some parameters in the model which are common among different management factors? One can make such judgments based either on visual inspection of data or on statistical analysis. The goal is to simplify the analysis as much as can be justified. Throughout this analysis analytical functions have been used, in contrast to numerical procedures. A particular set of data for response of corn (Zea mays L.) to applied N, P, and K is used to illustrate the analytical procedures. The extended logistic model describes the data rather well. Coupling of biomass yield and plant N uptake is achieved with a hyperbolic phase relation. The memoir contains 36 pages, including 19 references, 21 tables, and 11 figures.

This book on “Crop Growth Simulation Modelling and Climate Change”. A group of authors have dealt with different aspects of crop modelling viz., Crop growth simulation models in agricultural crop production, Applications of Crop Growth Simulation Models in Climate Change Assessments, Biophysical impacts and priorities for adaptation of agricultural crops in a changing climate, Climate change projections – India's Perspective, Impact of Rising Atmospheric CO2 concentration on Plant and Soil processes, Modelling the impact of climate change on soil erosion in stabilization and destabilization of soil organic carbon, Simulating Crop Yield, Soil Processes, Greenhouse Gas Emission and Climate Change Impacts with APSIM, InfoCrop Model, CropSyst model and its application in natural resource management, Climate change and crop production system: assessing the consequences for food security, A biophysical model to analyze climate change impacts on rainfed rice productivity in the mid-hills of Northeast India, AquaCrop Modelling: A Water Driven Simulation Model, Conservation Agriculture: A strategy to cope with Climate Change, Effect of climate change on productivity of wheat and possible mitigation strategies using DSSAT model in foot hill of Western Himalayas, Integrating Remote Sensing Data in Crop Process Models, Climate change impact assessment using DSSAT model, Decision Support System for Managing Soil Fertility and Productivity in Agriculture, De-Nitrification De-Composition Model - An Introduction for SOC Simulations, Crop Simulation Modeling for Climate Risk assessment: Adaptation and Mitigation Measures and Rules of Simulations, Rothamsted Carbon (RothC) Model and its Application in Agriculture etc. Under leadership of CT de Wit a large amount of modeling, building prototypes and also application, was carried out in the 1970s and 1980s. Comprehensive models were built, evaluated and carefully documented in the areas of crop growth production, plant breeding, soil water and nutrients, and in crop protection. Simulation techniques and biophysical theories developed in parallel. Simulation and experimentation always went hand in hand. Much of this work is documented in a long series of PhD theses under supervision of De Wit, in the series of Simulation Monographs (PUDOC), and in numerous other publications. This work has inspired many scientists across the global science community. The CT de Wit Graduate School of Production Ecology (PE) of the Wageningen University builds further on this platform and finds new subjects for research on and with models, and data. The PE platform provides also an excellent opportunity to develop contacts, cooperation and joint software with research groups in related fields and abroad. This book precipitates from such an exploration in new directions. We realize that modem information systems and statistics can offer a substantial contribution to the modelling framework. Good examples can be found here, and these provide a clear direction for the years to come.

A discussion of challenges related to the modeling and control of greenhouse crop growth, this book presents state-of-the-art answers to those challenges. The authors model the subsystems involved in successful greenhouse control using different techniques and show how the models obtained can be exploited for simulation or control design; they suggest ideas for the development of physical and/or black-box models for this purpose. Strategies for the control of climate- and irrigation-related variables are brought forward. The uses of PID control and feedforward compensators, both widely used in commercial tools, are summarized. The benefits of advanced control techniques—event-based, robust, and predictive control, for example—are used to improve on the performance of those basic methods. A hierarchical control architecture is developed governed by a high-level multiobjective optimization approach rather than traditional constrained optimization and artificial intelligence techniques. Reference trajectories are found for diurnal and nocturnal temperatures (climate-related setpoints) and electrical conductivity (fertirrigation-related setpoints). The objectives are to maximize profit, fruit quality, and water-use efficiency, these being encouraged by current international rules. Illustrative practical results selected from those obtained in an industrial greenhouse during the last eight years are shown and described. The text of the book is complemented by the use of illustrations, tables and real examples which are helpful in understanding the material. Modeling and Control of Greenhouse Crop Growth will be of interest to industrial engineers, academic researchers and graduates from agricultural, chemical, and process-control backgrounds.

Water stress and heat stress are considered to be two primary factors that limit crop production in many parts of the world. Global warming appears to be increasing the water requirements of plants. Understanding the impact of water deficit on plant physiological processes and efficient water management are of great concern in maintaining food production to meet ever increasing world food demand. The book addresses various climatic soil and plant factors that contribute to the water use efficiency in plants subjected to water stress. It covers all issues related to soil, plant and climatic factors that contribute to the crop responses to water stress. The books advances the knowledge in improving and sustaining crop yields in ever increasing unpredictable climatic fluctuations This book uses crop simulation models for response of crops to limited water under various management and climatic conditions. Highlighting effective, analytical functions that have been found useful for the comparison of alternative management techniques to maximize water and nutrient resources, this reference describes the application of viable mathematical models in data analysis to increase crop growth and yields. Featuring solutions to various differential equations, the book covers the characteristics of the functions related to the phenomenological growth model. Including more than 1300 literature citations, display equations, tables, and figures and outlining an approach to mathematical crop modeling, Mathematical Models of Crop Growth and Yield will prove an invaluable resource.

Why model? Agricultural system models enhance and extend field research...to synthesize and examine experiment data and advance our knowledge faster, to extend current research in time to predict best management systems, and to prepare for climate-change effects on agriculture. The relevance of such models depends on their implementation. Methods of Introducing System Models into Agricultural Research is the ultimate handbook for field scientists and other model users in the proper methods of model use. Readers will learn parameter estimation, calibration, validation, and extension of experimental results to other weather conditions, soils, and climates. The proper methods are the key to realizing the great potential benefits of modeling an agricultural system. Experts cover the major models, with the synthesis of knowledge that is the hallmark of the Advances in Agricultural Systems Modeling series.

This text quantifies the impact of climate change on rice production using crop simulation models, and integrates existing knowledge of the effects of increased levels of carbon dioxide and temperature

Evapotranspiration is a very complex phenomenon, comprising different aspects and processes (hydrological, meteorological, physiological, soil, plant and others). Farmers, agriculture advisers, extension services, hydrologists, agrometeorologists, water management specialists and many others are facing the problem of evapotranspiration. This book is dedicated to further understanding of the evapotranspiration problems, presenting a broad body of experience, by reporting different views of the authors and the results of their studies. It covers aspects from understandings and concepts of evapotranspiration, through methodology of calculating and measuring, to applications in different fields, in which evapotranspiration is an important factor. The book will be of benefit to scientists, engineers and managers involved in problems related to meteorology, climatology, hydrology, geography, agronomy and agricultural water management. We hope they will find useful material in this collection of papers.

This is the story of tropical agricultural science and agricultural development in the 20th century, focusing on the African farmer and African farming methods. It describes successes as well as fads and failures, many based on the author’s first-hand observations during more than 40 years in tropical agronomy-related fields. Moving into the 21st century, the book explores the rise of computer modeling of crops and crop production.

The demand for crop production is rising on a global scale. The increased demand must be met with increased production. The increase can be achieved by expanding crop growth areas or crop yields on current arable land on a global scale. Whether and where a yield increase is possible needs to be assessed on a global scale. van Wart et al. (in press) developed a protocol to assess the potential yield in a consistent way on a global scale. Based on land use data the major crop growth areas are selected and crop growth modeling is performed to assess the potential (Yp) and water limited (Yw) yield. Out of the average farm yield (Ya) and the potential or water-limited yield the yield gap closures (Ya/Yp or Ya/Yw) are derived. The closure can be used as a benchmark to compare different regions to each other. The protocol of van Wart et al. (in press) involves the selection of a set of weather stations that cover at least 50% of national crop growth area in their 100 km buffer zones. The protocol is tested in an application on winter barley, winter wheat and winter rape seed in Germany. Global gridded data sets of the year 2000 and current national statistics were employed to derive the land use and yield data of all crops for the protocol. The protocol could be performed on the basis of the land use out of the national statistics for winter barley only. The land use data for winter wheat and winter rape seed out of the national statistics did not lead to a fulfillment of all criteria in the protocol of van Wart et al (in press). For the representative study area the major soil types were selected and water-limited and potential yields were assessed with two calibrated and validated crop growth models, i.e. HERMES (Kersebaum, 1995) and WOFOST (Boogaard, 1998). The actual yields derived out of the gridded data set of 2000 were 16% lower for winter rape seed, 11% lower for winter barley and 4 % lower for winter wheat compared to the actual yields derived from the national statistics around 2008. The yield levels were estimated for multiple soil types within the buffer zones of the weather station and aggregated to the national scale. The yield gap fractions related to the water-limited yields (Yw) were 80%, 88% and 95% for winter barley, winter rape seed and winter wheat, respectively. A sensitivity analyses on the effect of buffer zone radius on the number of weather stations to cover at least 50% of the national crop growth area was performed. In addition a sensitivity analysis of the effect of the number of selected soil types within the 100 km buffer zones of the selected weather stations on the coverage of national production area was performed.

During the 1978 growing season a growth analysis was performed on potatoes (Solanum tuberosum L.) planted on 2 February and 14 March. Two cultivars, Monona and Sebago, were studied. During the winter of 1979 a thermogradient analysis of Sebago growth was conducted. The objective of these studies was to provide data for the development and validation of a mathematical crop growth and development model. During the summer and fall of 1979 such a crop model was written in the GASP IV simulation language. The purpose of the crop model was to elucidate the effects of temperature on assimilate partitioning. The results of the crop growth and development model indicated that the primary effect of soil temperature was through a direct regulation of the tuber growth rate which had a 15° C temperature optimum, A high potential tuber growth rate stimulated photosynthesis; so a secondary effect of soil temperature was on net daily photosynthesis. The major effect of air temperature was its influence on the tuber initiation date. Air temperature and tuber initiation rate were inversely related. The air temperature also affected the rate of canopy senescence with warm temperatures speeding leaf drop and reducing the crop growth rate. The main weakness of the model was that light interception data were input rather than generated by the model itself.

"Crop Modeling and Decision Support" presents 36 papers selected from the International

Symposium on Crop Modeling and Decision Support (ISCMDS-2008), held at Nanjing of China from 19th to 22nd in April, 2008. Many of these papers show the recent advances in modeling crop and soil processes, crop productivity, plant architecture and climate change; the rests describe the developments in model-based decision support systems (DSS), model applications, and integration of crop models with other information technologies. The book is intended for researchers, teachers, engineers, and graduate students on crop modeling and decision support. Dr. Weixing Cao is a professor at Nanjing Agricultural University, China.

The study was on the performance of the decision support system for agrotechnology transfer (DSSAT) and the soil water atmosphere plant (SWAP) under an acid sulphate soil. The comparison of these models was done as a prerequisite to the selection of an appropriate model, which is capable of simulating water management scenarios, water balance and crop growth, to be coupled with an adaptive optimization algorithm that can be used to explore water management options.

This dissertation describes efforts to move toward a completely integrated remote sensing and crop growth modeling tool for developing precision nitrogen management recommendations for corn. Aerial hyperspectral remote sensing imagery collected throughout the 2004 growing season was used to estimate corn plant stand density, and a machine vision system was used to map corn population on the ground. Multiple linear regression analysis was used to assess the ability of all combinations of three reflectance bands to estimate corn plant population at resolutions of 2 m, 6 m, and 10 m. Coefficients of multiple determination of up to 0.82 were achieved in this endeavor. Although some limitations apply, remote sensing can be used as a tool to provide corn plant population inputs for crop growth simulations. A cross validation technique and bivariate confidence ellipses were used to evaluate CERES Maize simulations of spatial corn yield variability across an Iowa cornfield. Results indicated that the model performed most poorly when using the wettest or driest growing seasons to validate the model, because the model parameters fitted under the conditions of moderate growing seasons were less flexible for simulating yield in growing seasons with more extreme weather. Results also indicated that topography affects the model performance spatially. CERES-Maize was also used to simulate yield and unused nitrogen remaining in the soil at harvest for a sequence of historical weather data. Simulations were run for 13 spring-applied nitrogen rates over a cornfield divided into 100 0.2 ha grid cells. A methodology based on cumulative probability distributions was then developed to use model output for assessing the link between yield and nitrogen left behind for various nitrogen rates in each grid cell. This methodology can be used to develop precision nitrogen management strategies that address both the economic and environmental concerns of nitrogen management practices. Although the three projects in this dissertation furthered the development of remote sensing, crop growth modeling, and decision support technologies, more work is required to obtain a completely integrated tool for development of precision nitrogen management strategies in Midwestern cornfields.