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FOREWORD

A Word from the Editor

The successful implementation of the 2030 Agenda for Sustainable Development and the achievement of the Sustainable Development Goals depend on progress in agriculture. Agriculture has far-reaching implications in terms of poverty eradication, food security, health and wellbeing, biodiversity, climate change and economic development.

The most important goal of the 8th International Agriculture Symposium "AGROSYM 2017" – held in Jahorina on 05-08 October, 2017 – was to promote sustainability principles in agriculture. Sustainable agriculture is an important element of the overall effort to make human activities compatible with the demands of the earth's eco-system. Thus, an understanding of the different approaches to ecological agriculture is necessary if we want to utilize wisely the planet's resources. One of the goals of the sustainable agriculture movement is to create farming systems that eliminate, or at least mitigate, environmental harms associated with industrial agriculture. That aim can be realized only with context-specific agro-ecological practices; these depend on regional characteristics, climate conditions, soil types as well as socio-cultural, institutional and political settings.

AGROSYM 2017 made an important contribution to agriculture science and practice. Symposium themes cover all branches of agriculture and are divided into seven sessions: 1) Plant production, 2) Plant protection and food safety, 3) Organic agriculture, 4) Environment protection and natural resources management, 5) Animal husbandry, 6) Rural development and agro-economy, and 7) Forestry and agro-forestry.

During the four-day Symposium approximately 250 papers were presented orally and 1030 as posters. The contributions, representing the current research in different countries, were presented to more than 1300 participants from more than 85 countries. We are encouraged by the great success of this year's edition of AGROSYM 2017.

This publication is comprised of an edited selection of over 400 papers submitted to AGROSYM 2017. Each paper included in the present Proceedings was positively reviewed by two referees. Full texts of the submitted communications are also available online (http://www.agrosym.rs.ba). Some selected papers will be published in AGROFOR International Journal (http://www.agrofor.rs.ba/), International Journal "Agriculture and Forestry" (www.agricultforest.ac.me) and EcoPersia (www.ecopersia.modares.ac.ir). Many thanks to all the authors, reviewers, session moderators and colleagues for their help in editing the Proceedings. The results reported here will contribute to the dissemination of knowledge to the wider audience about the importance of agri-food science; one of the most important areas of research strategies in Europe and beyond.

AGROSYM 2017 was made possible through the commitment and contributions of a wide range of partners and sponsors. I take this opportunity to thank all of them and I look forward to a successful joint organization of AGROSYM 2018.

East Sarajevo, 23rd October 2017



Prof. Dušan Kovačević, PhD
Editor in Chief

MANAGEMENT OF GREENHOUSE CROP GROWTH SYSTEM

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Abstract

In recent decades, the greenhouse area has risen to grow the vegetables, ornamentals and fruit crops at worldwide year-round. Today, the greenhouse farming has been carried out in modern production facilities. The greenhouse management is a key factor at all growing stages, different timescales and market patterns. The sub-sectors such as energy, climate and water-fertilizer crop quality, and pest-disease in greenhouse can be integrated under management concept. In this paper, the hierarchical manager method is proposed for profitable and sustainable crop growth and production in greenhouse. This method involves three layers named as climate and nutrition manager layer, crop growth manager - layer and tactical manager layer. The greenhouse management is carried out based on fast crop dynamics (transpiration, photosynthesis, and respiration), and slow crop development (crop growth and fruit changes). High-tech greenhouses can be managed according to the strategic, tactical and operational levels based on computer, sensors, communication, and software sub-systems.

Keywords: *Greenhouse, Greenhouse management, Multilayer hierarchical control.*

Introduction

A modern greenhouse is a plant factory where a lot of equipment is used to control the growth and development of the plant (Dayioglu, 2014). Greenhouse is a complex system along with physical and biological environment. The crop is its main element directly influenced from different variables, such as weather variations (temperature, humidity, photosynthetic active radiation [PAR], and carbon dioxide concentration) nutrition (water and nutrients), biotic (pests, diseases, viruses, bacteria, and weeds), and cultural management (pruning, spraying). Today, the greenhouse farming has been carried out by using automation technologies in modern production facilities (van Straten *et al.*, 2011). The crop production at large-scale greenhouses requires a lot of energy, water and chemicals. In recent years, it is accepted that greenhouses consist of sub-sectors of crop, water-fertilizer, climate, energy, crop quality (Dayioglu, 2014). Some authors have studied on energy management (Kolokotsa, 2010), climate management (van Henten, 1996), water-fertilizer management (Pardossi *et al.*, 2011), crop management (De Pascale and Leonardi, 2012), quality and pest-disease management (Albajes *et al.*, 2000). These sub-sectors along with automation, computer and sensor technologies can be considered for the sustainable production. All those sectors and technologies required for greenhouses can be integrated for a successful management. Modern greenhouses can be managed by using the hierarchical control architecture derived from industrial automation systems (Scattolini, 2009). There are seven layers for industrial automation systems: 1) primary technology, 2) sensors and actuators, 3) low level control, 4) group control, 5) supervision, 6) manufacturing, 7) enterprise. These layers are configured for greenhouse climate in Watergy project (Speetjens *et al.*, 2008). The crop growth system can be defined by using a hierarchical control architecture. In this paper,

the hierarchical manager method is proposed for profitable and sustainable crop growth. The integrated management concept based on crop is defined for smart greenhouses.

Material and Methods

Greenhouses are equipped with many sub systems to meet the climate and nutritional requirements of crops. Sub-systems such as heating, ventilating, cooling, shading and fogging are used to control the greenhouse climate. Irrigation and fertilization sub systems are combined with dosing systems suitable to the soilless culture. The modern greenhouses can be managed as to the simplified automation scheme shown in Figure 1.

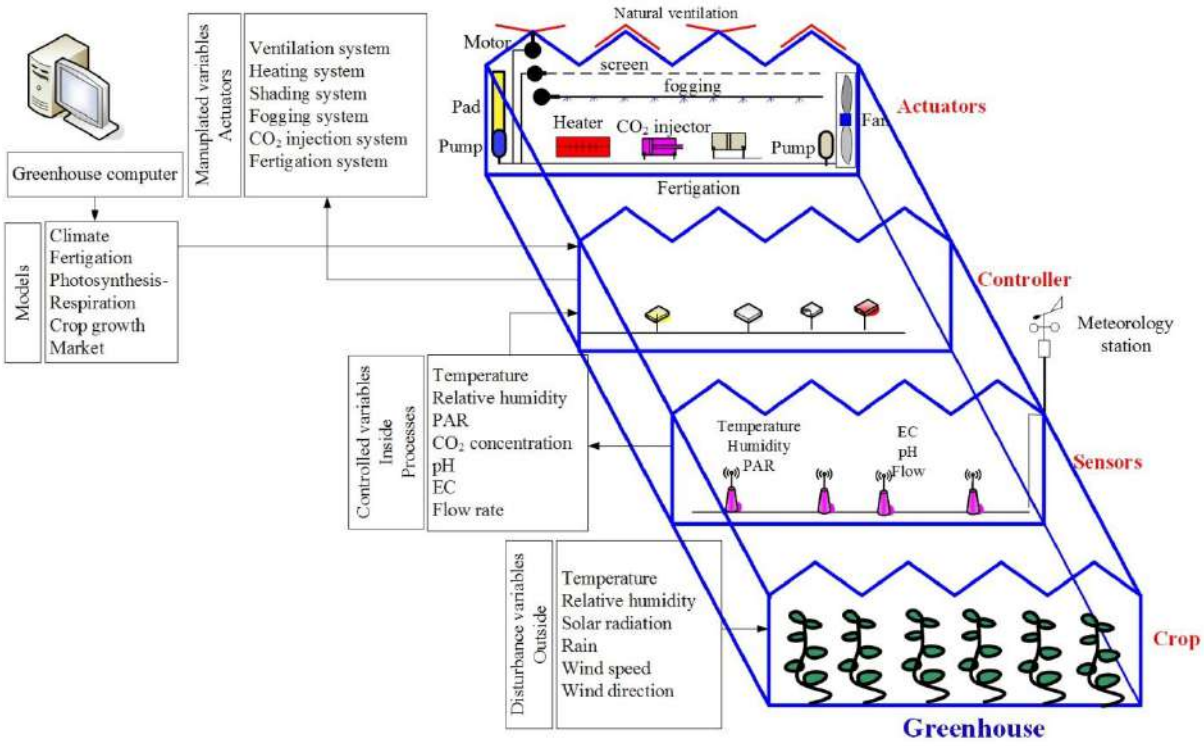


Figure 1. Greenhouse automation scheme

In this scheme, the modern greenhouse components such as crop, sensors, controllers, actuators are stratified to illustrate processes realized in background. Greenhouse processes are controlled in conformity with information flows among sensors, controller, and actuators. The disturbance variables including temperature, relative humidity, solar radiation, wind speed and direction at outside of greenhouse are taken into account for the successful climate management. Inside variables such as temperature, relative humidity, PAR, CO_2 concentration, pH, electrical conductivity (EC), water flow rate to be controlled according to seasons, day – night courses and crop growing levels must be properly set. Greenhouse computers are used so that farmers and/or engineers can follow the climatologic and nutritional variables and the control parameters, pest-disease and crop status, as well as alarm information arranged automatically. The control algorithms, expert software, predictive crop growing models are the most important tools for modern greenhouses. The dynamic models are used to define the knowledge among all the interactions and processes, to obtain efficient automation and optimum crop growth (Fortuna *et al.*, 2000). The wired systems such as Ethernet, RS485, CAN, ModBus and/or wireless systems including Bluetooth, WiFi ZigBee, as well as GSM for long range (Serodio *et al.* 2001; Pawlowski *et al.*, 2009) are need for the successful management.

Hierarchical Manager Method

The greenhouse-crop growth system can be managed by *“hierarchical manager method”* with three layers in the light of information given by (Ramirez-Arias *et al*., 2012; Rodríguez *et al.*, 2015). In this method, three layers are defined at various the time scales such as seconds/minutes, minutes/hours, months/season, hours/days: (1) *Climate and nutrition manager layer, (2) Crop growth manager layer, (3) Tactical manager layer.* Furthermore, three different levels are taken into account at hierarchical control architecture: (1) *Real system level, (2) Model level, (3) Controller level.* Figure 2 shows schematically the application of the hierarchical manager method with three layers defined for greenhouses:

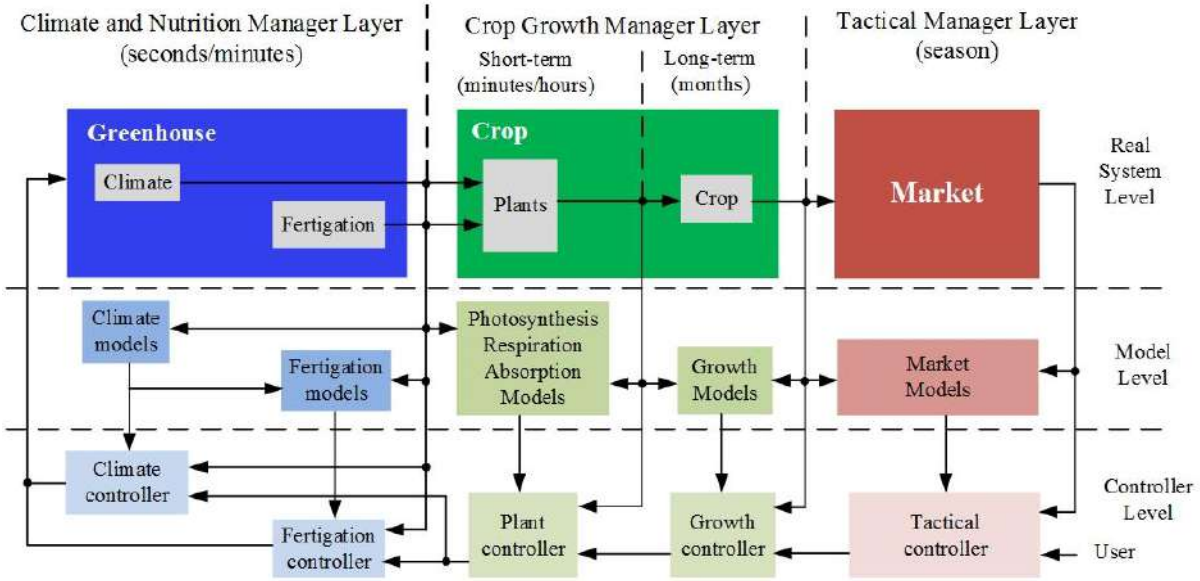


Figure 2. Hierarchical manager method with three layers (modified and adapted from Rodríguez *et al.*, 2015)

Results and Discussion

Greenhouses can be managed by the hierarchical control approach to provide the optimum crop growth based on economic criteria. We offer a hierarchical control scheme for greenhouses. Hierarchical layers consist of climate and nutrition manager layer, crop growth manager-layer and tactical manager layer. The proposed hierarchical control scheme corresponds to that given by Ramírez -Arias *et al*. (2012) and Rodríguez *et al.* (2015).

- *Climate and nutrition manager layer* is responsible from computing of control signals to be sent to the actuators by using temperature and EC set-points calculated by the tactical manager layer. The control algorithms such as feed-forward control, adaptive control, predictive control and hybrid control have been proposed for greenhouse control (Rodriguez et al., 2008; Rodríguez et al., 2015).
- *Crop growth - manager layer* finds the growth trajectories from tactical manager layer and calculates the set points suitable air temperature and electrical conductivity (EC) trajectories for the greenhouse crop according to long-term and short-term weather predictions. The daytime and night-time temperature levels and the EC set points are calculated. Generally, this layer is divided into two levels: Short-term growth control, Long-term growth control.
  - *Short-term growth control:* The physiological processes such as photosynthesis or crop respiration, which directly influence the crop growth, are taken place at

temporal horizon of hours. In this level, the set points for the next day are calculated by using short-term weather predictions, the actual state of the crop, and the short-term grower goals according to crop status.

- *Long-term growth control:* This contains the decisions about the total production schedule of the crop. These decisions are taken by using information based on the growing rate, vegetative features and the crop specific climatic set point values. The main variables are the dry matter production and leaves production matching with the crop growth process. Thus, the climatic and irrigation set points are calculated according to probable harvesting date or an expected growth curve.

- *Tactical manager layer* solves the optimization problem that is defined for different objectives. The outputs of this layer are the growth trajectories limited by the crop to maximize the profit. The long-term objectives and the long-term predictions are taken into account. The long-term objectives are market prices, harvesting dates, and required quality.

The greenhouse climate is managed according to outputs of climate model and climate controller. The fertigation process is controlled with outputs of fertigation model and fertigation controller taken from optimization procedure of tactical manager layer. The mechanisms of decision support of greenhouse are defined from crop growth models. The fertigation balance is set from crop growth and market variations. The growth models of crop are affected from market models defined in tactical layer. Many devices including sensor and actuator, and expert model and software are used to control the climate and fertigation processes.

Smart greenhouses can be designed based on *"hierarchical management method"* defined in above and *"integrated management concept*" shown in Figure 3.

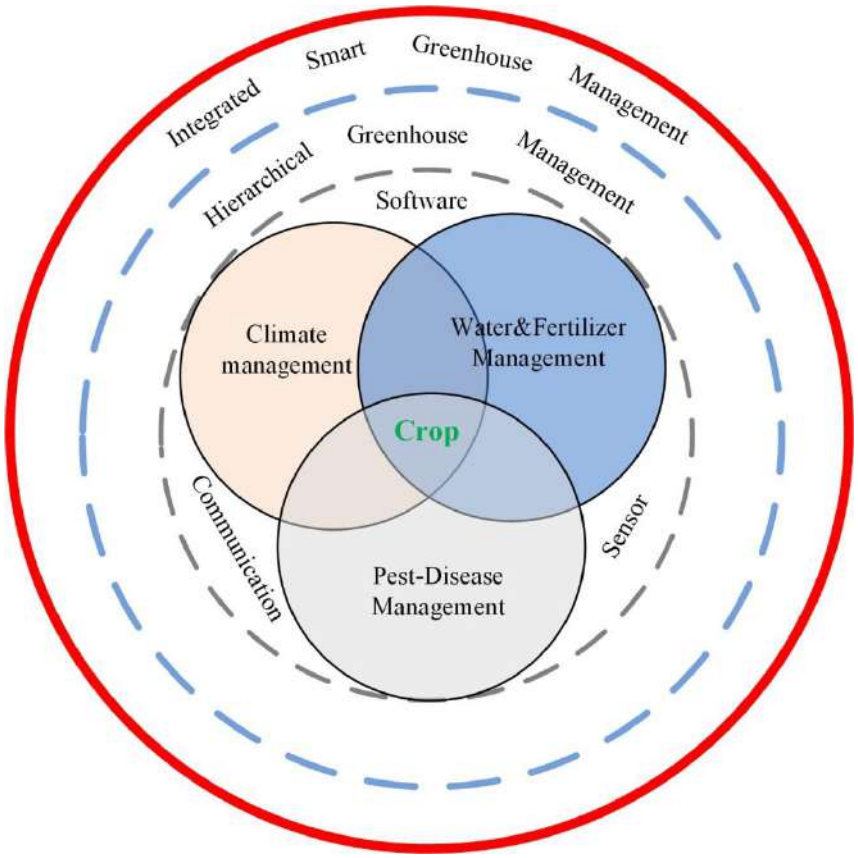


Figure 3. Integrated smart greenhouse management

The sophisticated greenhouse management relies on the use of information and automation technologies including monitoring and controlling of all processes in the production cycle for high quality products (Aaslyng *et al.*, 2005). Furthermore, the integrated smart greenhouse management is planned to be provided the following outputs:

- Increasing in production,
- Decreasing in product cost,
- Improving in product quality,
- Decreasing in labor use,
- Flexible use for coming up with short-term and long-term targets,
- Decreasing in energy use,
- Increasing the efficiency in using of energy,
- Using of alternative energy sources and industrial waste heat,
- Decreasing in greenhouse gas emission,
- Decreasing in environmental pollutions and wastes,
- Decreasing in pesticide use.

Conclusions

The greenhouse is a closed environment where climate and fertigation processes must be controlled for ideal crop growing. The greenhouse agro-system is a complex system including physical, chemical and biological processes in which are take place simultaneously. Therefore, the crop growing conditions can be just controlled by sub-systems including heating and screening system, ventilating system, cooling and shading system, fogging system, CO_2 injection system, irrigation and fertilization system and automation system, as well as transportation and packaging. Greenhouses can be managed by using hierarchical methods like an industrial facility. Modern greenhouses can be operated as smart facilities based on the integrated management concept and hierarchical method. The management organization for greenhouses can be integrated based on energy and climate management, water-fertilizer management, disease-quality management. Greenhouse computers are the strategical devices to manage the climate and fertigation procedures of greenhouse. These are usually programmed based on crop and market models. High-tech greenhouses can be run at the strategic, tactical and operational levels by using computers, sensors, wired-wireless communication and software sub-systems. Information detailed about physical, biological, and chemical environments of the greenhouse can be obtained by using wireless sensor nodes and actuators to be placed to different positions.

References

Aaslyng J. M., Ehler N. Jakobsen L. (2005). Climate control software integration with a greenhouse environmental control computer, Environmental Modelling & Software 20: 521-527.

Albajes R., Gullino M. L., van Lenteren, J. C., Elad Y. (2000). Integrated Pest and Disease Management in Greenhouse Crops, Kluwer Academic Publishers, pp.545, New York

Dayioglu M.A. (2014). Intelligent Greenhouses: Integrated Hierarchical Management, pp. 301-307, Proceedings of 12th International Congress on Mechanization and Energy in Agriculture (ADAGENG2014)", 3-6 September 2014, Cappadocia-Nevsehir.

Fortuna R.L., Nunnari G., Occhipinti L., Xibilia M. G. (2000). Soft computing for greenhouse climate control. IEEE Transactions on Fuzzy Systems; 8(6):753–760.

De Pascale, S., Leonardi C. (2012). Greenhouse Crop Management: New Approaches to an Old Challenge, Proc. IS on GreenSys2011 343-350, Eds.: C. Kittas et al. Acta Hort. 952, ISHS 2012.

Kolokotsa D., Saridakis G., Dalamagkidis, K., Dolianitis S., Kaliakatsos I. (2010). Development of an intelligent indoor environment and energy management system for greenhouses, Energy Conversion and Management, 51, 155–168.

Pardossi A., Carmassi G., Diara C., Incrocci L., Maggini R., Massa D. (2011). Fertigation and Substrate Management in Closed Soilless Culture, Pisa, pp:1-63.

Pawlowski A, Guzman J.L, Rodriguez F., Sanchez M.B.J., Dormido S. (2009). Simulation of greenhouse climate monitoring and control with wireless sensor network and event-based control. Sensors, 9: 232–252.

Ramírez-Arias A., Rodriguez F., Guzmán M.B.J.L., Berenguel M. (2012). Multiobjective hierarchical control architecture for greenhouse crop growth, Automatica, 48, 490–498.

Rodriguez F., Guzman J. L., Berenguel M., Arahal M. R. (2008). Adaptive hierarchical control of greenhouse crop production, International Journal of Adaptive Control and Signal Processing, 22:180–197.

Rodríguez F., Guzmán M.B.J.L., Ramírez-Arias A. (2015). Modeling and Control of Greenhouse Crop Growth, Springer.

Scattolini R. (2009). Architectures for distributed and hierarchical Model Predictive Control – A review, Journal of Process Control, 19,723–731.

Serodio, C., Cunha, J. B., Morais, R., Joao C. C. (2001). A networked platform for agricultural management systems Monteiro Computers and Electronics in Agriculture 31, 75–90.

Speetjens S.L., Janssen, H.J.J. van Straten, G.Gieling, Th.H., Stigter J.D. (2008). Methodic design of a measurement and control system for climate control in horticulture, Computers and Electronics in Agriculture, 64, 162–172.

van Henten, E.J., Bontsema J. (1996). Greenhouse climate control: a two time-scale approach. Acta Horticulturae 406: 213-219.

van Straten, G. van Willigenburg, G., van Henten, E. and van Ooteghem, R. (2011). Optimal Control of Greenhouse Cultivation, pp. 296, CRC Press.