Using Computer Control System in Tissue Culture Plant Acclimatization®

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INTRODUCTION

Briggs Nursery, a Washington State wholesale grower of perennials and woody ornamentals, produces 7 million plants annually in its tissue culture (TC) laboratory. The product line consists of some 700 cultivars in 125 genera. This diversity, combined with a range of pot and plug-tray types and sizes, as well as the highly sensitive nature of TC plant material, diverse rates of development, climatic requirements, varying uniformity, vigor and performance of cultures, and year-round production cycle make special demands on the acclimatization process. The size and complexity of acclimatization greenhouses and the need for round-the-clock flexibility with often rapidly changing weather, crop type, potting media, energy, and labor costs etc. makes an integrated, computerized control system a logical choice in an effort to manage acclimatization operation efficiently.

In the last decade, the integrated computer control systems specifically designed for horticulture have grown increasingly sophisticated and flexible, initial costs have decreased and increased energy efficiency and savings have become a major focus of the software as the price of fuels and electricity skyrockets. The savings advertised by Argus Control Systems according to surveys of their clientele are 20% savings in electricity, 30% to 75% savings in water usage, 30% to 50% savings of fertilizers, and 15% increase in labor productivity.

Even a relatively small but diversified operation, running perhaps a propagation greenhouse, hardening-off or acclimatization facility, and an order-assembly/staging greenhouse may benefit from installation of an integrated system that can control all three types of greenhouse regimes with highly diverse hardware from a single point, using one comprehensive controller rather than numerous series of stand-alone units in each section. Especially when future expansion is planned, a single integrated system is the obvious choice over stand-alone control units. A further benefit to the grower using modern greenhouse control software is the opportunity to share directly in the results of the latest research and continued efforts at improving efficiency as every advance is rapidly incorporated into the software and its updates.

INTEGRATED CONTROL SYSTEM STRUCTURE AND CAPABILITIES

All system functions are fully integrated; the software contains programs for all hardware operation including various types of irrigation equipment, motors, injectors, pumps, sensors, etc. It incorporates weather data collection, climate programs, irrigation and fertigation programs as well as access level features and alarm system, data archiving, system diagnostic tools, etc. One benefit of this integration is the harmonized manner in which systems such as venting, space heaters, supplemental or photoperiodic light, mist, and bottom heat will operate. Since this equipment is run by a single controller that also monitors trends in temperature, humidity, etc., the performance of each component is optimized relative to the other parts

of the system and relative to trends in weather/house-climate conditions, resulting in energy savings while eliminating abrupt, all-or-nothing mode of operation as well as reducing wear and tear on the equipment.

A control system such as Argus, which is used by Briggs Nursery, operates from a central master controller, with a PC used only to communicate with the system and archive data not essential to system's operation. The master controller has its own nonvolatile memory and built-in emergency power supply and will remain immune to power failure for days. The system network supports up to 60 master controllers and each master controller in turn supports up to 32 expansion boards. Each expansion controller serves as a repeater "daisy-chained" to others, making cheap connection over vast areas possible. The system is accessible via modem, LAN, or wireless network as well as locally by portable PC. Remote operation and call-grower-at-home alarm features add an extra level of flexibility and protection. The entire system is fully accessible by the grower/operator but on-line support and Argus staff assistance during operation is also readily available.

IRRIGATION SYSTEM SETUP

You can divide your irrigation needs into several separate systems, and further divide each system into branches with their specific water and up to four different feed capacities. Pump pressurization delay settings, purging, valve-opening delays, valve capacities, etc., make volume and pressure management as well as prioritizing irrigation needs possible. The system also features shutdown due to malfunction and manual override utilities.

Each irrigation program can operate over 30 different irrigation schedules and control 60 different equipment devices. Individual zones (or in our case TC acclimatization benches) can be set up with their individual set of parameters such as valve capacity, irrigation priority, and base watering duration. Irrigation decisions can be based on various types of control including manual, time clock, accumulation (based on the rate of accretion of chosen value to a set threshold), and equation (based on a logical relationship of three different conditions). For instance, a light energy accumulation program will monitor the amount of energy accumulated over time ($W \cdot m^{-2}$) and will trigger a misting burst when a threshold amount of accumulation is reached. The rate of accumulation will vary throughout the day and with it the frequency of misting. Even the duration of misting bursts or the threshold and number of bursts can be modified and automatically manipulated based on the amount of accumulation or time of day and the schedule can further incorporate a time-based decision, morning, mid-day, evening, and night interval schedule, priority assignment, ramped or stepped transition to next schedule (e.g., from rooting to hardening-off), etc. The software is highly flexible and capacious; every conceivable crop can be accommodated with its custom program and there is no need to shoehorn the range of plant types into one generic template of care regime. You can tailor an irrigation schedule to a specific plant development stage or crop type, combine various schedules in a single zone, operate on the scale of seconds and minutes as in TC acclimatization or on a scale of hours, days and weeks all within one system, as well as select various alarm settings.

LIMITATIONS OF CURRENT SYSTEMS AND A PEEK INTO THE FUTURE

The current computer control systems are set up by the grower to meet the plant's needs as these needs are perceived and interpreted by the grower. Similarly, the conditions in the greenhouse are managed according to sensors gathering data from a limited portion of the environment, often removed from the majority of the crops. Delays in judgment and action are inevitable as trends in the plant's development and physiology or environmental changes are initially subtle and are often vastly out of optimal range by the time they become discernible or detectable by current methods. The nascent phytomonitoring technology, focused on gathering physiological data (stem flux rate, leaf temperature, CO_2 exchange, stem/leaf/fruit growth, etc.) directly from the plant as well as gathering environmental data directly from plant's immediate vicinity is a promising development. Integration of a phytomonitoring system with a greenhouse control system would enable the plant to have direct input in the greenhouse operation, thus optimizing the production process.

The current selection of commercially available greenhouse structures, for the most part, doesn't yet offer a system that would be able to utilize the waste heat, solar energy, or convection air movement in making the greenhouse at least partly capable of covering its own energy needs. Technologies such as heat storage via solar/water heat collectors, modern insulation, and siding materials and renewable energy systems in general should become standard features of a modern, energy-efficient greenhouse. Proposals are currently on the drawing board in various parts of the world to utilize the greenhouse structure's tremendous heat-generating potential not only to cover its own energy needs but also to supply power to in some cases thousands of households. Although still far from realization, such efforts are definitely a step in the right direction, making horticulture once again an integral part of life on this planet.

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