Emerging Need for Environmentally-Controlled Agriculture Training and Decision Support Tools

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For the past two decades, improving farm-production efficiencies by reducing inputs and environmental perturbations has been at the forefront of agriculture technology development. “Precision Agriculture” computational tools provide framework to manage resources and improve yields in relatively uncontrollable field landscapes (Brevik et al., 2016). Machine-to-Machine communications supported by intelligent interfaces shows promise to advance and boost food production (Ray, 2017). With decreasing access to locally grown foods in large urban environments, food justice and parity may only be possible if urban farm projects are established on building rooftops and abandoned industrial lands near cities (Horst et al., 2017). Thus, a new STEM precision agriculture is borne in controlled environment agriculture (CEA).

There is a need to develop CEA training tools in order to cultivate a rapid innovation-learning paradigm that supports CEA food production on Earth and beyond. The 1967 Outer Space Treaty promotes plans to occupy lunar and interplanetary landscapes, and establish farm systems that emulate Earth models under CEA production (Chang, 2017). Nutrient recycling, oxygen production, and increased water use efficiency through CEA biomass production are critical outcomes in maintaining food production sustainability (Sprecht et al., 2014; Wheeler, 2017).

Environmentally controlled greenhouse and poultry agriculture production has risen steadily since 2007 (USDA, 2017). In 2012, roughly 54,500 nursery, greenhouse, and floriculture specialty crop farms produced over $19 billion market value of products sold; a 47% increase in value of products from 2007 (Vilsack, 2015). The majority of greenhouse production facilities were family or individually owned yet only 25% of operators were female and ethnic diversity of greenhouse/nursery operators was low. Foreign competition has placed increased pressure on American horticulture to adopt more energy efficient production methods.

Animal feeding operations (AFOs) have also experienced similar increased productivity and product improvements with a move to EC systems. Today, critical environmental parameters, including temperature, humidity, lighting, and ventilation are maintained at acceptable levels in off-seasons (Kocaman et al., 2006; Zhao et al., 2015). However, poultry producers still face environmental management challenges associated with increases of AFO production scales and concerns of animal well-being, which requires new or modified housing and control systems (Mench et al., 2011; Yang et al., 2017). Cost-efficient environmental management solutions, based on simulations using integrated EC decision support tools, are needed to sustain the both greenhouse and poultry industries.

Opponents of CEA production warn input energy costs are a major drawback (Sprecht et al., 2014). However, localized CEA production energy offsets are gained when human spatial concentration taxes economies by separating goods away from points of ultimate consumption (Rosenburg, 1972). Computer-assisted production technology is integral to the realization of secure, robust food production, and this is especially true of food production on lunar and other interplanetary surfaces where EC systems are compulsory. Virtual reality training can induce empathy in users but controls and pedagogy are needed to prevent misuse of the technology (Bailenson, 2018).

Imagine a protective training scenario where greenhouse and poultry students enter into a virtual training environment and construct a “virtual production facility” (in the augmented reality framework). Next, they determine what crop to grow, program the EC interface for the growing season, and plant the virtual green crop or flock in the facility. Daily, students check the crop progress by doing “virtual chores”, and they compare production outcomes to the programmed EC interface parameters and predictions. A student-user receives warnings of impending problems or diseases requiring mitigation. In sufficient “virtual fertilizer” or setting the incorrect “virtual long-day lighting schedule” might result in lower than average “tomato crop”. Failure to fill the “virtual power generator” with “virtual diesel” might cause a broiler flock to perish in a “virtual extreme heat” scenario (students will require a “virtual reset” to the point of lost production after explaining the crop failure in writing). At the end of the growing cycle, the student measures their “virtual profit” based on farm production outcomes developed within their scenario. Virtual reality CEA training scenarios will be useful in a broad range of educational settings including secondary, post-secondary, and industry settings. Conversely, the FGT software will serve researchers wanting to “reverse engineer” production outcomes through retroactive modeling. Secure and safe pedagogical methods can ensure proper use of the tools for all ages.

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