Research Poster

Building Knowledge for Saline Agriculture through Controlled Environment Training: Evaluation of a Multi-Day Capacity-Building Workshop

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Introduction/need for research

Agriculture uses nearly 70% of global freshwater (UNESCO, 2024). Moreover, pressures from population growth, drought, sea-level rise, and saltwater intrusion are intensifying regional water scarcity (O'Donnell et al., 2024). These challenges threaten the sustainability of traditional crop systems and the ability to meet future food demand. In these contexts, Controlled Environment Agriculture (CEA) offers a practical solution by enabling crop production in enclosed systems that precisely manage environmental conditions and water use for maximum efficiency. Building stakeholder capacity and integrating their expertise into agricultural education and outreach are essential for advancing these innovative practices.

The Sustainable Agriculture Systems-Controlled Environment Agriculture (SAS-CEA) project addresses this need by promoting the use of saline and brackish water resources for cultivating salt-tolerant crops in controlled environments. As part of this effort, a five-day professional development training (June 23 – 27, 2025) was held at the U.S. Vegetable Laboratory in Charleston, South Carolina. The program engaged sixteen agriculture and science teachers and Cooperative Extension Agents in an intensive training program led by more than 15 project Co-PIs. By equipping educators and Extension professionals with applied knowledge and classroom-ready materials, the training served as a vital tool for translating SAS-CEA research into teaching, outreach, and local practice. The program combined hands-on activities and lectures to enhance participants' technical understanding of saline agriculture and CEA principles, with pre- and post-knowledge assessments used to evaluate learning outcomes.

Conceptual / Theoretical Framework

The training design was grounded in adult learning (Knowles, 1984) and experiential education principles (Kolb, 1984), emphasizing active engagement, demonstration, reflection, and application. The evaluation framework was informed by Kirkpatrick's Four-Level Model (Bates, 2004), focusing on Level 1 (Reaction) to assess participant satisfaction and Level 2 (Learning) to measure knowledge gain through pre- and post-assessments. Together, these frameworks ensured that the program was instructionally sound, learner-centered, and systematically evaluated for both engagement and learning outcomes.

Methodology

Participants (n = 16) from various backgrounds, i.e., Ag teachers and extension educators, attended nine sessions covering topics such as water use, water quality & salinity, desalination, salinity tolerance, brine management, controlled environment agriculture, plant water relations, tradeoffs between salinity levels and crop yields, and aquaponics. Each session included six knowledge questions (multiple-choice or true/false) administered as retrospective pre- and post-tests and reviewed by subject-matter experts to ensure content validity. After data collection, the responses were coded dichotomously (0 = incorrect, 1 = correct). Descriptive statistics were used to summarize participant demographics and mean percentage scores per session. Paired-samples t-tests examined overall and session-wise changes in knowledge. Correlations between knowledge gain and variables (education, work experience, prior CEA experience) were analyzed using Pearson's r or Spearman's rho.

Participants also completed a post-training evaluation survey to assess satisfaction related to workshop quality, relevance, and recommendations. Items on the survey were measured on a five-point Likert-scale items with 1 = strongly disagree to 5 = strongly agree, and open-ended questions to identify areas for improvement.

Results / Findings

The workshop participants (n = 16) represented a balanced group by gender (53.3% male, 46.7% female) and diverse educational backgrounds, including 40% with a four-year college degree, 46.7% a master's degree, and 13.3% additional graduate credentials. The average age was 39.9 years (SD = 10.0), with 14.8 years (SD = 7.2) of professional experience, and one-third (33.3%) reported prior knowledge of CEA.

Across nine sessions, participants' mean knowledge scores increased from pre- to post-test, demonstrating positive learning gains throughout the workshop. Pre-test means ranged from 38.54% (*Session 8: Tradeoffs Between Salinity Levels and Crop Yields*) to 83.33% (*Session 4: Improving Salinity Tolerance*), while post-test means ranged from 61.45% (*Session 8*) to 90.62% (*Session 9: Aquaponics*), reflecting substantial improvement after instruction. Sessions with higher pre-test scores (*Sessions 4 and 7*) showed smaller relative gains but maintained strong overall performance. A paired-samples t-test showed a statistically significant increase in scores from pre-test (M = 0.60; SD = 0.16) to post-test (M = 0.77; SD = 0.13), with $t\ (15) = 7.70$, $p < .001$, with a mean increase of 0.17 points (d = 1.92, 95% CI [0.12, 0.22]). No significant relationships emerged between knowledge gain and work experience, education, or prior experience with CEA.

Participants rated training quality very highly, with 100% agreeing that the workshop provided useful, well-organized information, and 73% rated it "excellent" overall.

Conclusions

Participants demonstrated significant knowledge gains across nearly all technical areas, confirming the effectiveness of the saline-CEA training in strengthening understanding of controlled environment and saline agriculture concepts. The results highlight the value of structured, multi-day experiential learning for translating research innovations into applied skills. The absence of correlations between knowledge gain and participants' education, prior CEA experience, or work tenure indicates that the training was equally effective across diverse backgrounds.

Implications / Recommendations / Impact

This evaluation demonstrates a replicable approach for building capacity in saline agriculture-based CEA. Future programs should include a follow-up survey to measure behavior change and adoption (Kirkpatrick Level 3) and explore online or hybrid delivery models to expand training reach and sustain impact across regions.

References

Bates, R. (2004). A critical analysis of evaluation practice: the Kirkpatrick model and the principle of beneficence. *Evaluation and program planning*, *27*(3), 341-347.

Knowles, M. S. (1984). *Andragogy in action: Applying modern principles of adult learning.* Jossey-Bass.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development.* Prentice Hall.

O'Donnell, K. L., Bernhardt, E. S., Yang, X., Emanuel, R. E., Ardón, M., Lerdau, M. T., Manda, A. K., Braswell, A. E., BenDor, T. K., Frankenberg, E., Helton, A. M., Kominoski, J. S., Lesen, A. E., Naylor, L., Noe, G., Tully, K. L., White, E., & Wright, J. P. (2024). Saltwater intrusion and sea level rise threatens US rural coastal landscapes and communities. *Anthropocene*, *45*, 100427. https://doi.org/10.1016/j.ancene.2024.100427

UNESCO (2024). Water for Prosperity and Peace. UN World Water Development Report. Statistics | UN World Water Development Report