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FEATURES

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Can Edamame Go High-Wire?

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When I first entered the controlled environment agriculture (CEA) industry as an undergraduate student at Virginia Tech University, I was excited to begin researching ways to broaden the scope of what could be grown in hydroponic systems. While listening to lectures and working with different production systems in class, I was impressed by the potential of CEA. But I also noticed that much of the conversation centered around leafy greens.

1. Edamame pod grown utilizing a Dutch bucket system at Virginia Tech University.

Leafy greens are important and they've helped build the foundation for many hydroponic operations. However, if CEA is going to continue developing as a tool for food production, I believe we also need to consider how these systems can support a wider range of crops, including protein-rich and nutrient-dense options. I questioned whether legumes could be produced hydroponically, and after five years of gaining a greater understanding of hydroponic production and plant physiology, I decided to explore that question further. For this study, I started with edamame.

Edamame from field to greenhouse

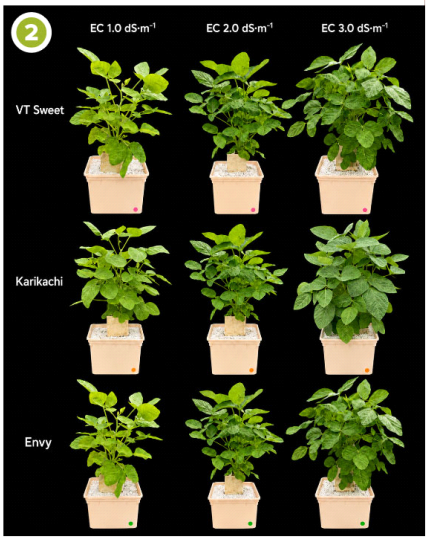
Edamame, or vegetable soybean [Glycine max (L.) Merr.], originated in Asia and has become increasingly popular in American cuisine over the last several decades. Known for its high protein and fiber content, edamame is commonly sold as a fresh or frozen vegetable and harvested before the crop reaches the dry stage used for conventional oil seed production.

In field production, edamame can face challenges related to regional climate, seasonality and environmental variability. These challenges influence yield, uniformity and overall crop quality. As climate conditions continue to shift and growers look for new ways to produce high-value crops, it's worth asking whether edamame could be adapted to CEA production systems.

This doesn't mean greenhouse edamame will replace field production. Instead, the goal is to ask a more focused question: Can edamame be grown successfully in a hydroponic greenhouse system and, if so, what

production factors are most important?

For growers, this question matters because crop diversification isn't just about novelty. New crops need to fit into existing systems, use space efficiently, produce a marketable product and justify the added learning curve. Before any crop can be considered a realistic option, researchers must first understand whether the plant can establish, flower, produce a marketable yield and respond predictably to controlled greenhouse management strategies.



Matching edamame with the right system

CEA allows growers to directly manage factors such as light, temperature, relative humidity, irrigation, nutrition, pH and electrical conductivity. Additionally, hydroponic systems have become more diverse as growers and researchers continue to explore crops with different growth habits.

Systems such as nutrient film technique (NFT), ebb and flow, and deep water culture (DWC) are commonly used for short-cycle and shallow-rooted crops such as leafy greens and herbs. Fruiting crops and crops with larger root systems and longer production cycles often require systems that provide more root-zone volume and support for vertical growth. Dutch bucket production was selected for this study since edamame is a fruiting crop.

2. Graph depicting the color and growth variations across cultivar and fertility treatment of the hydroponically produced edamame.

Dutch buckets aren't always the first system people think of in commercial CEA production, but they hold value when evaluating crop performance. Because each plant is grown in an individual bucket, it's easier to observe plant growth, compare treatments and manage a crop with a larger root system. Perlite is a commonly used substrate in Dutch buckets because it provides good aeration and allows for precise fertigation management. This makes for a useful starting point for introducing and investigating a novel crop such as edamame into CEA.

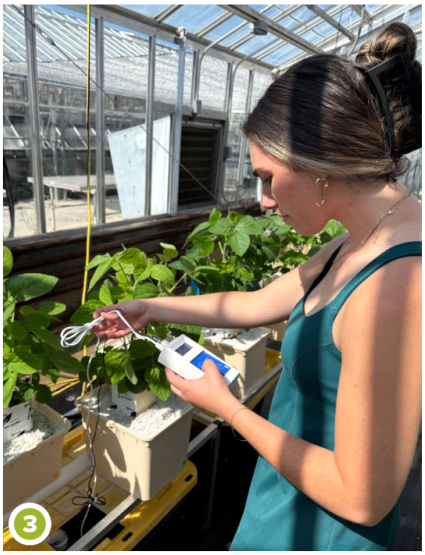
High-wire production was also an important factor in this project. If indeterminate edamame cultivars can be trained vertically, the crop may be better suited for greenhouse production where space, plant architecture, production cycles and labor efficiency are important considerations.

Cultivar selection and fertility evaluation

Because limited research has been published on edamame as an alternative crop for high-wire Dutch bucket production, the first step was to determine which factors were the most important to evaluate. Cultivar selection was the most notable question to ask. Most edamame cultivars on the market have been evaluated primarily under field conditions, so it was important to observe how different cultivars performed in a hydroponic greenhouse system.

For this study, the cultivars Karikachi, VT Sweet and Envy were selected because of their indeterminate growth habit and high germination rate. These cultivars were evaluated to determine whether their growth characteristics were suited for high-wire Dutch bucket production.

Fertility was another key factor to evaluate. The electrical conductivity of the nutrient solution was set at 1.0, 2.0 or 3.0 $dS \cdot m^{-1}$ to evaluate how fertility influences establishment, plant nutrition and reproductive efficiency. These treatments provide a starting point for learning how edamame responds to different nutrient strengths in hydroponic production.



Early observations

Preliminary observations have shown that edamame can establish successfully in a Dutch bucket hydroponic system. Germination exceeded 90% in rockwool cubes and transplants were able to establish well after being moved into the production system. This was an important first step because a novel hydroponic crop must be able to move successfully from germination to transplant establishment before other production questions can be answered.

3. Ellie Gregoire checking the electrical conductivity, pH and reservoir temperature of the fertilizer solution of the edamame.

Fertility also appears to influence plant architecture and health. Plants grown at 1.0 $dS \cdot m^{-1}$ displayed nutrient deficiency through chlorosis, and reduced plant height. Plants grown at 3.0 $dS \cdot m^{-1}$ were fuller and had darker green leaves. These early observations suggest that fertility management will play an important role in successful hydroponic production of edamame.

Differences were also observed among cultivars. Four weeks after transplanting, Karikachi and Envy began setting pods, while VT Sweet hadn't completed flowering. These differences are important for growers to note because crop timing, flowering, pod set and harvest predictability all influence whether a crop is practical and profitable in a greenhouse system.

This work is still ongoing, and final yield and quality data over time will be needed before stronger production recommendations can be made. However, these early observations are promising for the future of edamame in CEA.

Yes, it is possible!

Through this study, preliminary results suggest that edamame grows effectively within a Dutch bucket hydroponic system. The crop germinated well, established after transplanting, responded visibly to fertility treatments and began producing pods under greenhouse conditions. While there's still much to learn, this creates an exciting opportunity for future research.

As we expand upon our understanding of edamame within hydroponics, we must continue to ask key questions pertaining to production and how researchers and growers can navigate potential challenges. How

long can indeterminate edamame remain productive? What harvest schedule would make sense for extended crop seasons? How does greenhouse-grown edamame compare in quality to field-grown edamame? And, eventually, could this crop become economically realistic for greenhouse growers?

As CEA continues to evolve, I believe it's important to remain curious and open to innovative ways to expand upon our current understanding. Leafy greens will continue to play a major role in hydroponic production and field agriculture will remain essential for crops like soybean. However, there's also a need to explore new crops that provide improved nutritional value, growth habits and market opportunities into controlled environments.

This research began with a question that once seemed unrealistic: Can legumes be grown hydroponically? Based on what we've seen so far, the answer is yes. Now the challenge is learning how to grow them well. **IG**

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