Use of Aquaponics as a Secondary Crop and Effluent Treatment in Ponds, Raceways, and Recirculating Tank Systems

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Abstract

The objective of this study was to investigate the growth and nutrient uptake potential of native ornamental plant species, Crimson-eyed Rosemallow (*Hibiscus moscheutos* L.) and Blue Flag Iris (*Iris versicolor* L.), integrated into three different freshwater aquaculture production systems which primarily dominate in the Northeast U.S. which include: flow-through raceways, recirculating systems and ponds. These systems are relatively expensive to operate and are faced with increasing environmental regulations associated with effluent management. West Virginia University has partnered with University of Maryland and Delaware State University to evaluate the integrating aquatic ornamental plant culture with aquaculture production. Aquatic plant culture for ornamental and restoration markets has proven to be an emerging industry with high value crops. In addition, aquatic plants can be an important means of nutrient uptake. Therefore, the concept of integrating aquatic plants for aquaculture effluent management has potential to increase farm income through diversification and help aquaculture producers manage fish effluent. Research was conducted during the active growing season in 2006 (April - September) for all three production systems. Each University had one of the three aquaculture systems; trout flow-through raceway (WVU - West Virginia), striped bass recirculating tank (UMD - Maryland), and a baitfish pond (DSU - Delaware). Data collected included: total plant biomass production and total nitrogen and phosphorus percentages. Results indicated that nutrient uptake from the raceway and pond was negligible. However, plant growth was significant in the recirculating and pond systems. These results indicate that ornamental crop production may be viable for added income and limited effluent nutrient uptake.

Introduction

As aquaculture faces continued pressure from the environmental community and increased governmental regulations, efforts are being made to further improve production efficiency and decrease the environmental impacts of the industry. In the United States, perhaps the most important environmental concern facing the aquaculture industry is the disposal of the nutrient rich effluent water produced during the culture of aquatic animals.

Aquatic plant species have been evaluated for reduction of nutrients in a variety of water bodies for livestock waste and state environmental agencies commonly recommend shoreline plantings of several key species in stormwater ponds and artificial wetlands (Mitch and Gosselink, 2000). DeBusk et al. (1995) identified the phosphorus uptake of arrowhead, arrow arum, cannas, lizards tail, pickerelweed and cattail through tissue analyses with uptake rates of 52, 5, 173, 13, 66 and 47 mg/m^2-day respectively in treating dairy wastewater. Ayes et al. (1995) showed that cannas lily had very high nutrient removal rates of 2,620 mgN/m^2-day and 330 mgP/m^2-day. Reddy (1983) determined the nitrogen and phosphorus uptake for cattail (50 and 1.0 mg/m^2-day) and nitrogen uptake of an invasive species, water hyacinth at 5,440 mg/m^2-day. In addition to nitrogen and phosphorus uptake, aquatic plants have been shown to be effective in trapping sediments and taking up other pollutants associated with wastewaters (Hargis, 1998).

This project was designed to provide aquaculture farmers in the Northeast with several mechanisms and milestones to become informed and implement a new alternative crop with minimal infrastructure requirements yet higher returns than typical foodfish species currently produced. Aquatic plants sold for ornamental or restoration markets are very high value relative to food fish which often result in profit of $0.05 - 0.20 per pound depending on species, season, and market type. Wholesale prices for larger plant specimens range from $1.00 – $4.50 each. To maximize the number of potential beneficiaries and subsequent application on farms, various project activities of workshops, training and pilot scale research systems, will address the three most common production systems used in Northeast fish aquaculture; raceways, recirculating tanks and ponds. In each of the three systems aquatic plant integration can be accomplished through simple addition of low-cost shallow (15 – 20 cm of water) plant channels made from either lumber or concrete block and pond liner material. Aquatic plants will be floated within these raceways using a raft material developed by an aquatic nursery and project collaborator, Maryland Aquatic Nurseries.

Research Objectives

To conduct a plant species/market survey to determine which plants are most suitable for the aquaculture systems.

To evaluate and demonstrate 3 different aquaponics systems at three different locations based on different fish culture systems; flow-through raceway (WVU) (Fig 1.), baitfish ponds (DSU) (Fig 2.), and recirculating tanks (UMD) (Fig 3.).

To provide growers with technical support and implementation.

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Figure 1. Trout flow-through raceway facility

Figure 2. Baitfish pond facility

Figure 3. Striped Bass Recirculating Tank Facility

Figure 4. Plant growing channels in high tunnel structure utilizing flow-though system

Figure 5. Plant growing channels outside utilizing baitfish pond system

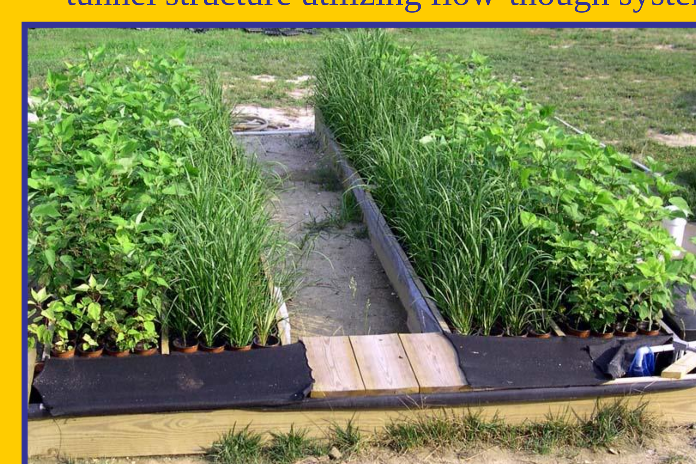

Figure 6. Plant growing channels outside utilizing recirculating system

Figure 7. Plant growing channels in high tunnel structure (June 12, 2006)

Figure 8. Plant growing channels in high tunnel structure approximately 6 weeks after Figure 7. (July 26, 2006)

Figure 9. Growth comparison of blue flag iris after 20 weeks (left – greenhouse, right – aquaponics high tunnel facility)

Figure 10. Growth comparison of Crimson-eyed hibiscus after 20 weeks (left – greenhouse, right – aquaponics high tunnel facility)

Figure 11. Insect damage on Crimson-eyed Rosemallow grown outside utilizing baitfish pond and recirculating aquaponic systems

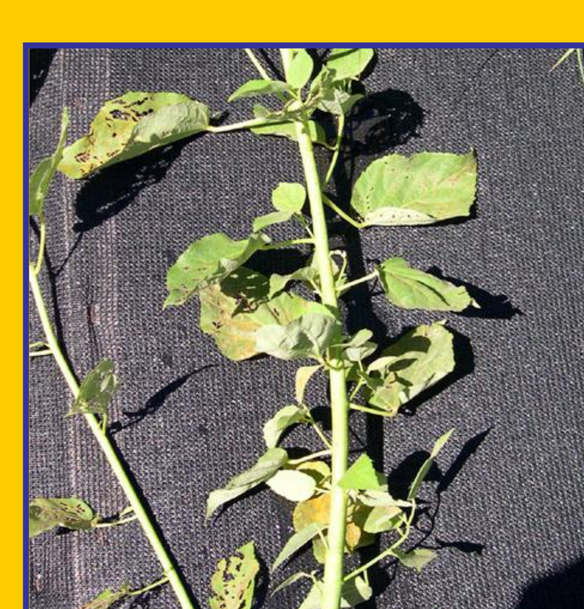

Figure 12. Insect damage on Crimson-eyed Rosemallow grown outside utilizing baitfish pond and recirculating aquaponic systems

Methods

Research Site: Three research sites were used based on the aquaculture production system; trout flow-through raceway (WVU - West Virginia), striped bass recirculating tank (UMD - Maryland), and a baitfish pond (DSU - Delaware).

Plant Selection: Two plants species (Crimson-eyed Rosemallow and Blue Flag Iris) were selected for growing in the three different system based on hardiness and potential salability of aquatic based ornamental plants. The striped bass recirculating tank system only had the Crimson-eyed Rosemallow growing in the system.

Experimental Design: Each plant species were randomly placed in a single growing channel. The growing channels had three replications for a total of six channels at each research site (Fig 4., 5., & 6.). Each plant channel was 5.5 x 0.6 x 0.23 meters and contained 72 plants.

Data Collection: Plant biomass was recorded at the beginning and end of the fish growing season (April - September) to determine a relative growth rate. Initial plant size were assessed prior to the placement of plant in the respective pond rafts. In addition, plant tissue samples were tested for total nitrogen (TN) and total phosphorus (TP) to determine nutrient uptake rates. All data were analyzed using the General Linear Model (GLM) of SAS to determine the significance of treatment effects.

Results & Discussion

Overall: The plant growth channels were found to be quite manageable for plant production. This system was labor efficient and required no watering of the plants. Utilizing the floating raft system, plants were easily rotated to account for nutrient gradients within the plant growth channels.

WVU – Trout flow-through raceway: Iris and hibiscus plants had limited growth as compared to the two other systems (Fig 7. & 8.). This is most likely because of the lower water temperatures (~12 C) and reduced nutrient availability as compared to the other two systems. Plants grown in the plant growth channels as compared to plants grown conventionally (utilizing a 20-20-20 slow release fertilizer) in a greenhouse were significantly smaller (Fig 9. & 10.). Nutrient removal from the fish effluent was negligible and insignificant. This systems was the only system not grown directly outside which utilized a high-tunnel structure with netting on the sides to exclude insects which resulting in salable quality plants being produced.

UMD – Striped bass recirculating tank: Hibiscus plants has a significant increase in growth as compared to the trout flow-through system. There was a 15.4% and 8.75% reduction of N and P respectively from the fish effluent used for plant production. A negative component of this system is that there was severe insect damage to the plants because of the lack of insect protection reducing the salability quality of the ornamental plants (Fig 11.).

DSU – Baitfish Pond: Although the changes in nutrient levels between plant channel in-flow and out-flow were not large enough to be statistically significant, there was a clear trend towards a reduction in total phosphorus as affected by plant uptake. Similarly, both the Crimson-eyed Rosemallow and the Blue Flag Iris appeared to thrive in the integrated system, increasing in weight by more than 500% and 550%, respectively. A negative component of this system is that there was severe insect damage to the plants because of the lack of insect protection reducing the salability quality of the ornamental plants (Fig 12.).

Conclusion

Results indicate that utilizing fish effluent as a nutrient source is limiting in flow-through systems as compared to pond and recirculating systems. There is potential for reducing nutrients in a recirculating system for plant growth. Utilizing fish production with a high tunnel structure could provide a sustainable growing system with limited with minimal infrastructure requirements yet higher returns than typical foodfish species currently produced by the grower. Further evaluation is needed and ongoing of each of the three aquaponic systems.

Literature Cited

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