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Giant Miscanthus Production on Maryland Eastern Shore's Marginal Land: Grassroots Efforts to Restore Profitable Agriculture

Abstract

Giant miscanthus (*Miscanthus* × *giganteus*) is a perennial warm-season grass that has been identified as a viable biomass crop with the potential to thrive on marginal lands. Marginal land on the Eastern Shore of Maryland is herein defined as lands experiencing saltwater intrusion, waterlogging, and severe deer pressure. In this field-scale study, we evaluated the establishment, biomass yield, and environmental stress tolerance of giant miscanthus on a 10-acre site in Dorchester County.

Crop establishment was successful indicating that miscanthus can survive marginal conditions and produce moderate yields of 2.8 tons per acre in the first year, with increases in the second year to 4.8 tons per acre only a 20% yield penalty compared to giant miscanthus grown on prime land on the Eastern Shore. Giant miscanthus demonstrated significant resistance to deer damage and was able to tolerate moderate soil salinity. However, higher sodium levels were correlated with lower plot yield. Giant Miscanthus also demonstrated resilience to intermittent waterlogging. The only areas of the field where miscanthus did not grow were areas with continuous waterlogging throughout the growing season and winter months. The study was limited by a two-year observation period and site heterogeneity.

Outreach efforts, including a field day, workshops and webinars, have successfully engaged the local farming community, raising awareness about the potential of this crop. Giant miscanthus shows promise as a profitable, sustainable alternative for marginal lands in the Mid-Atlantic coastal regions facing climate and other environmentally induced stressors.

Introduction

Giant miscanthus (*Miscanthus* × *giganteus*) is a perennial grass known for its high biomass yield and adaptability. This triploid hybrid is the result of a cross between *Miscanthus sinensis* and *Miscanthus sacchariflorus*, which have diploid and tetraploid ploidy levels, respectively. Triploid hybrids are sterile and do not produce viable seeds, so giant miscanthus is not able to become invasive via seed propagation (Wilson and Heaton, 2012). As a sterile hybrid, giant miscanthus must be propagated vegetatively, typically by rhizomes. Currently this hybrid is grown and used on the Eastern Shore of Maryland as a bedding material in poultry houses. It is functionally equivalent to traditional pine chip bedding but more sustainable. Giant miscanthus can also be used as a biomass crop for fiber-based products and as a bioenergy crop (Jacobson, 2024).

Marginal lands are increasingly common on the Eastern Shore of Maryland, exacerbated by the impacts of climate change and rising sea levels (Boesch et al., 2018). These areas, which are characterized by saltwater intrusion, waterlogging, and heavy deer pressure from both white-tailed deer and sika deer, are no longer suitable for traditional row-crop farming. As a result, many of these lands have been abandoned or have suffered from total yield losses in recent years. With the growing need for sustainable farming practices, there is interest in finding viable crops that can thrive in these challenging conditions while providing economic returns for farmers.

Giant miscanthus is known to tolerate a range of environmental conditions and has been identified as a promising alternative crop for marginal land in the region. This grass is well-suited for biomass production and has demonstrated the ability to tolerate moderate saltwater intrusion, intermittent waterlogging, and deer pressure, making it a potential candidate for revitalizing marginal farmland (Jayawardena et al., 2023; Stavridou et al., 2017). However, limited field-scale research has been conducted on its performance in Maryland's unique environmental conditions, particularly in areas subject to multiple stressors. This study evaluated the performance of giant miscanthus on marginal agricultural land in the Eastern Shore of Maryland, including its growth, biomass yield, and adaptability to challenging environmental conditions.

Project objectives

1) Research the growth and yield potential of giant miscanthus on 10-acres of marginal land. Researchers evaluated correlations between soil moisture and soil sodium content with giant miscanthus yield. Researchers also evaluated giant miscanthus tolerance to deer.

2) Foster regionally relevant education for farmers and landowners about growing giant miscanthus. The planting provided a field-scale demonstration of giant miscanthus for regional farmers. Through field-day and workshop events, the project educated regional farmers and the wider community about this crop and facilitated interest to discuss the viability of giant miscanthus as an option for marginal land.

Materials and Methods

Field site and experimental design

The research was conducted on a 10-acre field in Dorchester County, Maryland, which had experienced multiple consecutive years of total soybean crop failure due to severe flooding, saltwater intrusion, and high deer pressure. This site was chosen based on its representativeness of typical marginal land in the region. The field-scale planting of giant miscanthus enabled researchers to study a range of soil conditions and to observe deer behavior in a realistic environment. The site had Elkton and Mattapex silt loam soils, with 0-2% slopes. Elkton silt loam soils are classified as poorly drained, while Mattapex silt loam soils are classified as moderately well drained (Soil Survey Staff, 2025).

The field was divided into 20 plots of 0.5 acres each, using GPS technology to ensure accurate mapping and data collection (Figure 1). Half acre plots were intended to represent and capture the variation in nutrients, soil moisture, and soil sodium levels that existed within the field.

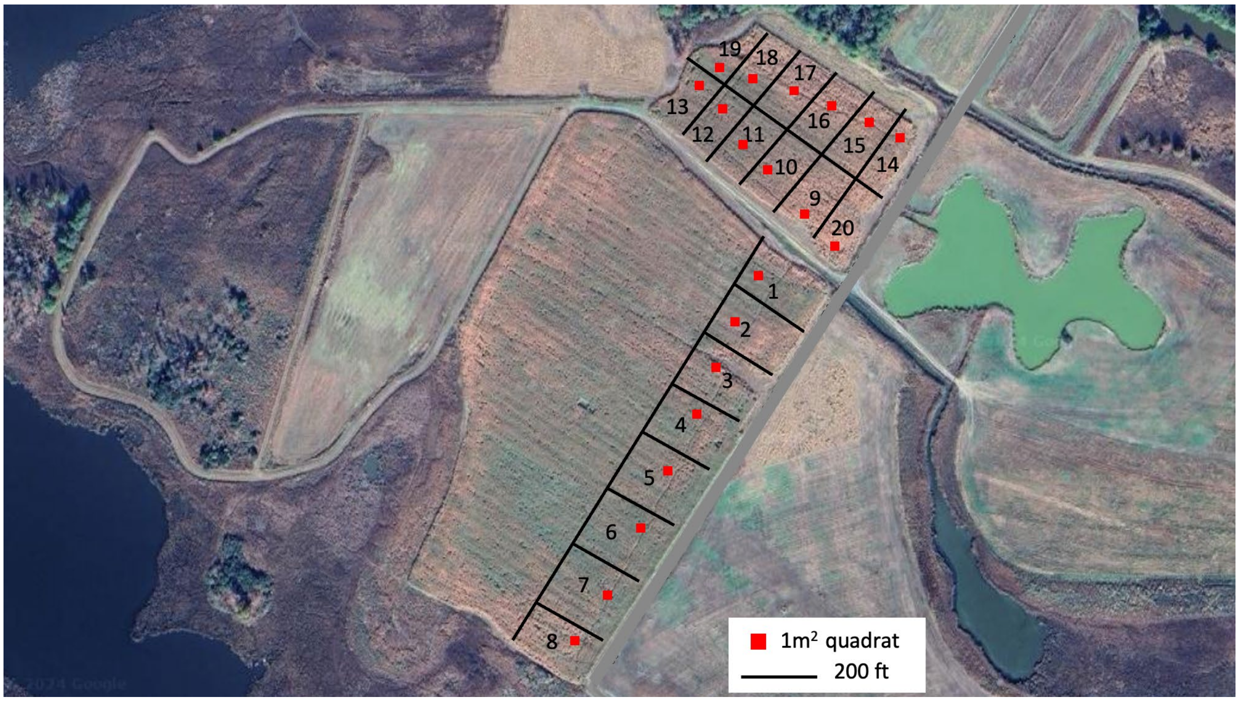

Figure 1. Samples were taken from 20 x 0.5 acre plots and 1m^2 quadrats.

Giant miscanthus planting and management

Giant miscanthus rhizomes were obtained from AGgrow Tech (patented material) and planted on June 7, 2022, two months later than initially anticipated due to weather and equipment availability. Rhizome counts were conducted on August 15, 2022, to assess establishment and emergence. Plant height was also measured at this time. Biomass yield data was collected from quadrats on March 10, 2023 and February 9, 2024.

Field conditions

Soil samples were taken in transects across each 0.5 acre plot to assess baseline soil characteristics, including pH, organic matter (OM), nutrient levels, and sodium content. Within each 0.5 acre plot, a 1 m^2 quadrat was selected along the transect (Figure 1).

Miscanthus yield, soil characteristics, and soil moisture was measured within these 1 m^2 quadrats. Quadrat soil samples were analyzed for pH, OM, nutrient levels, and sodium content. Soil moisture sensors were installed on January 7, 2022 in six of the 1 m^2 quadrats for continuous monitoring using Watermark 200SS sensors placed at five depths (2”, 6”, 12”, 18”, and 32”). Costs prevented soil moisture sensors from being installed in all 20 of the 1 m^2 quadrats. Sensors were positioned in quadrats to include a range of conditions, from wettest to driest.

To assess deer pressure on giant miscanthus, four giant miscanthus rows were walked on September 9, 2022 and October 26, 2022 to record the number of leaves that were grazed by deer. Two wildlife Bushnell wildlife cameras were installed on the edge of the field where deer tracks were observed to count the number of deer sightings during the first year of growth.

Data analyses

Linear regression analysis was conducted to examine the correlation between quadrat giant miscanthus yield and soil sodium content. Microsoft Excel was used for descriptive analysis.

Results

Giant miscanthus growth

The quadrats averaged 3.8 rhizomes per square meter with a range of three to seven rhizomes per quadrat. On August 15, 2022, plant height measurements ranged from 26 to 42 inches. By year two, at harvest, plant height ranged from 33 inches in the lowest yielding part of the field to 147 inches in the highest yielding parts of the field on February 9, 2024. Year one yields averaged 2.8 tons per acre, and year two yields averaged 4.8 tons per acre (Figure 2).

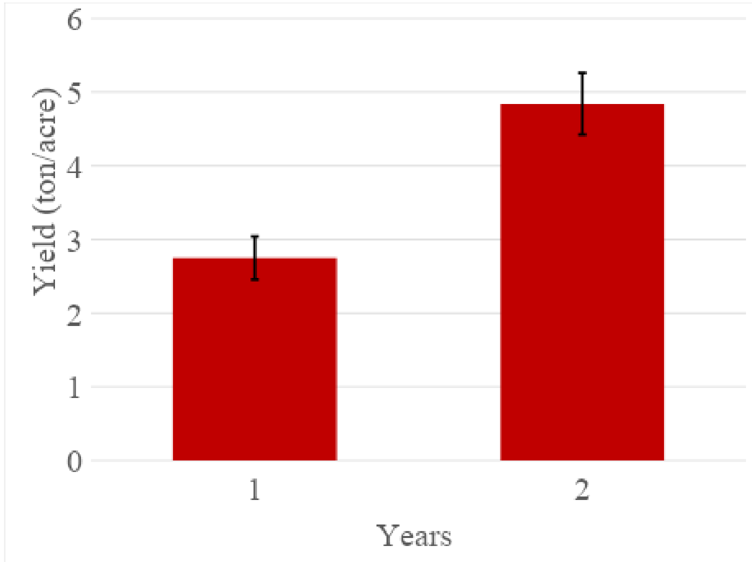

Figure 2. Average giant miscanthus yield (+/- standard error) from 20 1 m^2 quadrats within experimental field after first and second years of growth.

Field conditions

Based on the 0.5 acre plot transects, soil sodium levels were on average 317 ppm sodium and ranged from 120 to 620 ppm sodium which were all considered high by the based on the soil lab recommendations. The pH was on average 5.8 and ranged from 5.6 to 6.2. Organic matter was on average 2.6% and ranged from 2.1 to 3%. Cation exchange capacity ranged from 6.6 to10 meq/100g. Macro nutrients ranges were 6 to 23.2 nitrate-N ppm, 0.8 to 10.4 ammonium-N ppm 58 to 169 ppm, phosphorus, 45 to 182 ppm potassium. These soil values for phosphorous and potassium were all considered sufficient based on the soil lab recommendations for agronomic production of field crops, although some were low, none of the soil samples were considered deficient for phosphorous or potassium.

In the quadrats where miscanthus yield was measured, soil sodium levels averaged 174 ppm and ranged from 57 to 510 ppm. Higher concentrations of sodium correlated with reduced giant miscanthus biomass yield (R^2=0.37 in year one and R^2=0.18 in year two), more so in the first than second year (Figure 3). Based on the linear model, in the first year, quadrat yield was reduced by 0.2 tons per acre for every 100 ppm sodium. In the second year, yield was reduced by 0.6 tons per acre for every 100 ppm sodium.

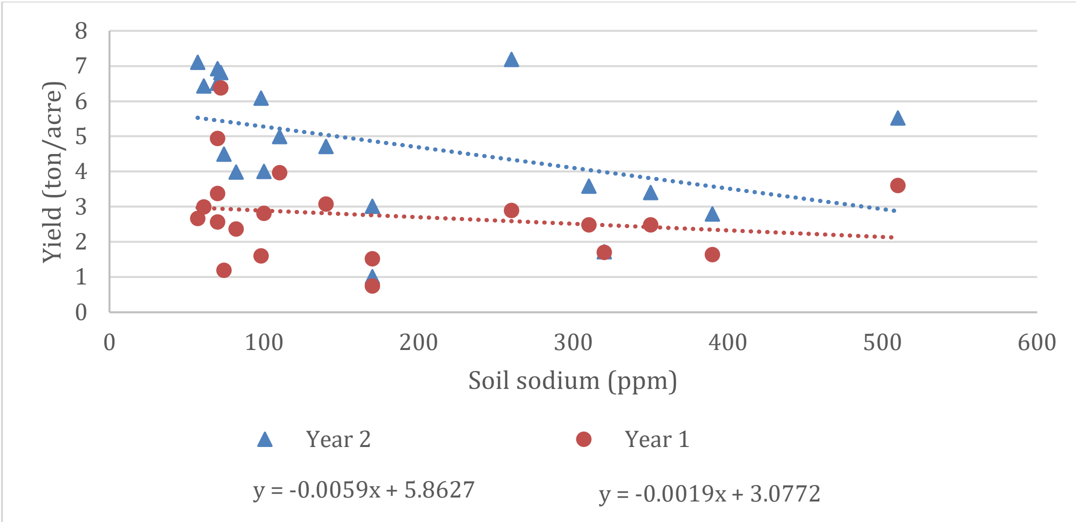

Figure 3. Correlation between giant miscanthus yields and soil sodium levels from 20 1-m^2 quadrats within the experimental field.

The field experienced persistent waterlogging in certain locations, while other sections of the field were subject to intermittent flooding during the growing season (Figures 4-6). Soil moisture probes buried at the 32" depth stayed saturated in all five locations. However, soil moisture probes located closer to the surface varied between the five locations (Figures 5-6). More variations in soil moisture were observed in the summer months of the growing season than in the winter when all five areas of the field tended to be saturated.

Figure 4. Giant miscanthus growing in waterlogged soil (left) and soil moisture data collection from wettest part of the field (right).

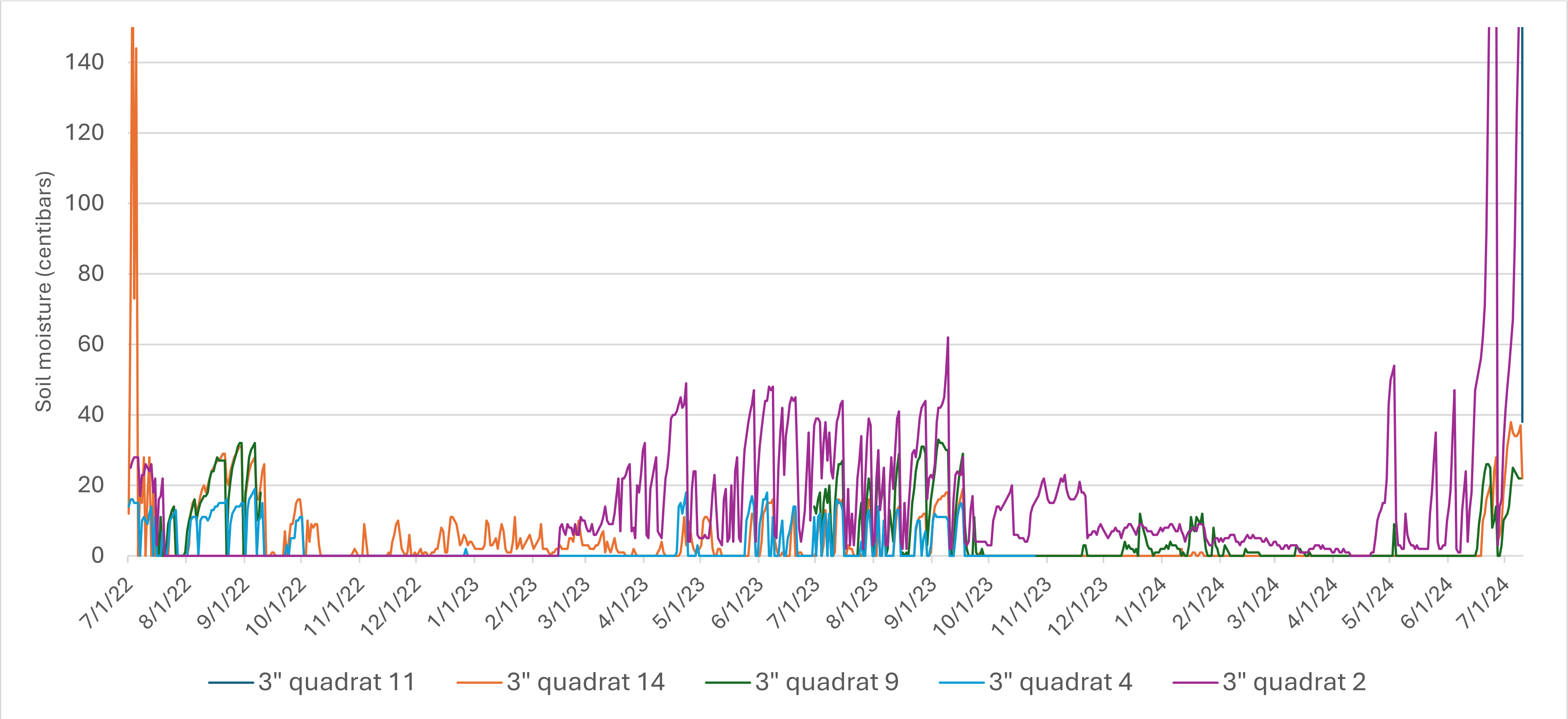

Figure 5. Soil moisture levels from 3" deep in five quadrats throughout the field from July 2022 through July 2024. Note that soil moisture probe for quadrat 11 sampled soil moisture from 7/1/22 to 7/10/24.

- Soil moisture probe for quadrat 14 sampled soil moisture from 7/15/22 to 9/9/22 and 6/29/23 to 7/10/24.
- Soil moisture probe for quadrat 9 sampled soil moisture from 7/1/22 to 10/25/23.
- Soil moisture probe for quadrat 4 sampled soil moisture from 7/1/22 to 7/19/22 and 2/15/23 to 7/10/24.
- Soil moisture probe for quadrat 4 sampled soil moisture from 7/1/22 to 7/19/22 and 2/15/23 to 7/10/24.
- Soil moisture probe for quadrat 2 sampled soil moisture from 12/15/22 to 2/18/23 and 10/25/23 to 7/10/24.

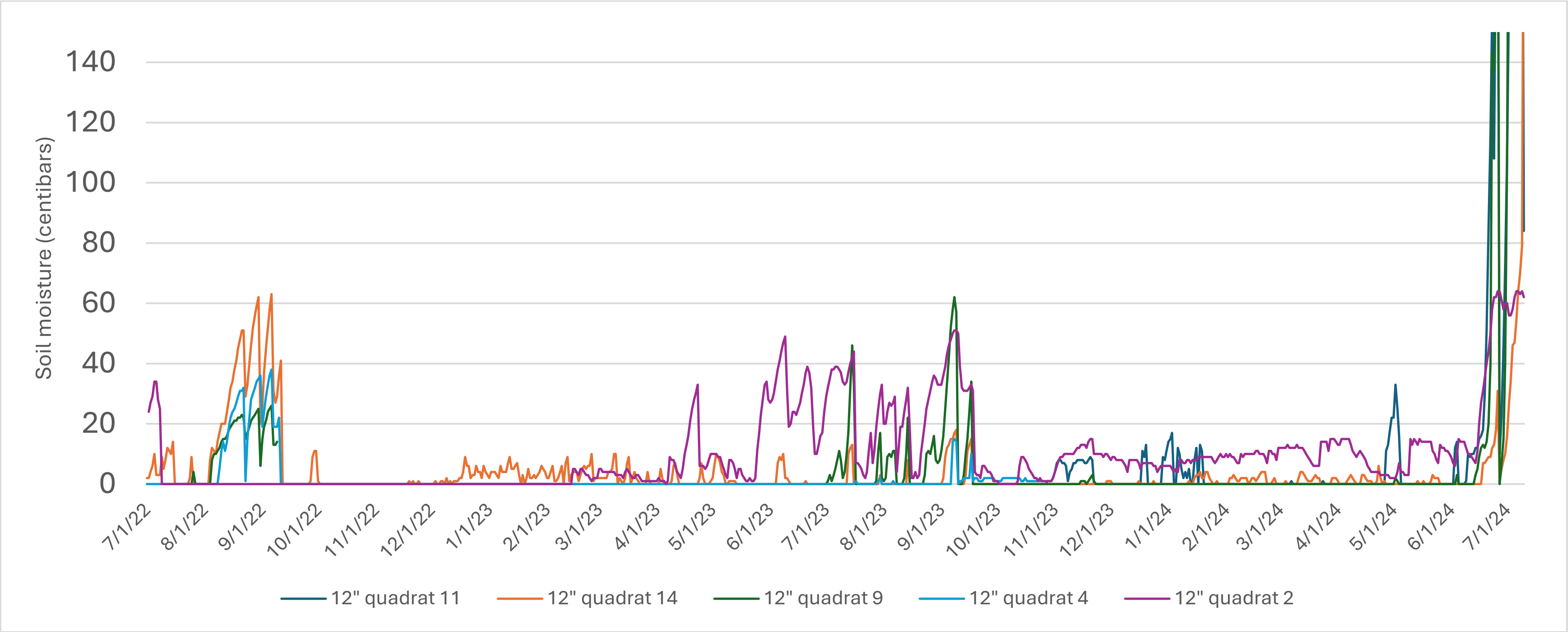

Figure 6. Soil moisture levels from 12" deep in five quadrats throughout the field from July 2022 through July 2024. Note that soil moisture probe for quadrat 11 sampled soil moisture from 7/1/22 to 7/10/24.

- Soil moisture probe for quadrat 14 sampled soil moisture from 7/15/22 to 9/9/22 and 6/29/23 to 7/10/24.
- Soil moisture probe for quadrat 9 sampled soil moisture from 7/1/22 to 10/25/23.
- Soil moisture probe for quadrat 4 sampled soil moisture from 7/1/22 to 7/19/22 and 2/15/23 to 7/10/24.
- Soil moisture probe for quadrat 4 sampled soil moisture from 7/1/22 to 7/19/22 and 2/15/23 to 7/10/24.
- Soil moisture probe for quadrat 2 sampled soil moisture from 12/15/22 to 2/18/23 and 10/25/23 to 7/10/24.

No deer grazing damage was observed in the field, despite heavy deer presence. During miscanthus emergence and establishment (June through July) deer sightings as captured by the wildlife camera per week ranged from 29 to 31. Later in the first growing season during giant miscanthus senescence when food sources for deer become scarce (October through December), deer sightings ranged from 12 to 62 (Figures 7 and 8). Deer paths and tracks were present through both growing seasons (Figure 8).

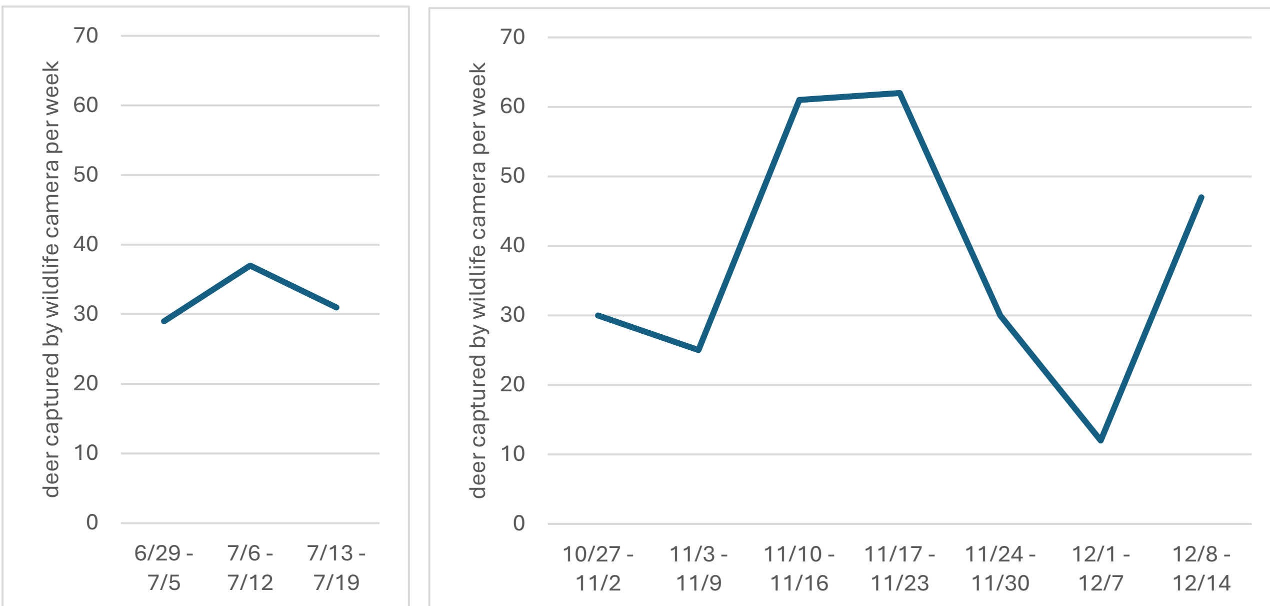

Figure 7. (Left) Deer captured by wildlife cameras in giant miscanthus field during miscanthus establishment in June and July of 2022.

(Right) Deer sightings per week during miscanthus senescence from October to December of 2022.

Figure 8. Deer image from Bushnell wildlife camera (left) and deer tracks within field (right).

Extension activities

As part of the project, numerous outreach activities were conducted to share findings with the farming community. These included field days, presentations at regional agricultural events, and webinars focused on miscanthus production and its potential as a crop for marginal lands. Notable outreach events included one field day with 29 attendees, one workshop with 20 attendees, six presentations reaching 582 participants, and two webinars with 196 viewers, with many more reached via online webinars recordings, posters, and popular media coverage in outlets including *Lancaster Farmer*.

Farmers and other attendees offered positive feedback and testimonials about the program. For example, one farmer called after the February 2024 field day and tour to share, “Excellent program today; I learned more today than I have in the past year.” Many participants expressed interest in growing giant miscanthus on their land, particularly if current barriers such as equipment availability and market access can be addressed. We are continuing to communicate with interested farmers and working toward the next steps of expanding markets and improving access to planting and harvesting equipment.

Figure 9. Field-day at giant miscanthus research site on February 20, 2024. Left two photos credit Haley Sater and right photo Emily Zobel.

Discussion

Miscanthus growth and biomass yield on marginal land

The results of this study indicate that giant miscanthus (*Miscanthus* × *giganteus*) has significant potential for cultivation on marginal lands, even in conditions characterized by saltwater intrusion, waterlogging, and high deer pressure. The average biomass yield was 2.8 tons per acre in the first year and 4.8 tons per acre in the second year. These yields were slightly lower than typical yields on prime land. Average first- and second-year yields on prime land for growing miscanthus would be 2.5-3 tons per acre and 6 tons per acre, respectively (personal communication with grower). Thereby the yield potential of giant miscanthus on marginal land based on our results is 80% of prime land. Previous studies report that giant miscanthus typically achieves higher yields under optimal conditions, with yields averaging 8-15 dry tons per acre once fully established, typically in the third year of production (Kalmbach et al., 2020). A longer-term study is needed to evaluate what the yield potential would be for giant miscanthus on marginal land and when it would reach that potential. The current research was not able to continue monitoring the giant miscanthus since the land changed ownership and production practices after year two.

Soil salinity and miscanthus tolerance

One of the most significant findings of this study was the crop's ability to tolerate high levels of sodium in the soil. The experimental field quadrats sodium concentrations ranged from 57 to 510 ppm, with an average of 174 ppm. Soil sodium levels for the 0.5 acre plots of the field were even higher, ranging from 120-620 ppm sodium with an average of 317 ppm sodium. These levels are considerably higher than typical row-crop soils in the region, where sodium levels usually range from 5 to 40 ppm (University of Delaware, 2024). Such high levels of sodium typically lead to yield losses in conventional crops like corn and soybean. In our study, giant miscanthus demonstrated tolerance to moderately high soil sodium conditions, but biomass yield tended to decrease as sodium levels increased. The data indicated that extremely high sodium levels can limit giant miscanthus productivity, especially in the second year, suggesting that while giant miscanthus can survive in salt-intruded environments, further research is needed to determine the threshold beyond which its growth is significantly impeded. The tolerance of giant miscanthus to sodium concentrations is consistent with other studies that have reported the ability for giant miscanthus to thrive under moderately saline and sodic conditions (Chen et al., 2017).

Waterlogging and growth impacts

While giant miscanthus grew well in intermittently saturated soil conditions, prolonged waterlogging impeded giant miscanthus growth. Areas of the field that experienced year-round waterlogging showed reduced plant height, weaker stems, lodging, and significantly reduced growth and biomass yield. This finding is in line with prior research, which suggests that although giant miscanthus has a robust root system capable of surviving waterlogged conditions, prolonged flooding can inhibit its growth potential (Kalmbach et al., 2020). Areas where soil moisture was saturated only intermittently during the growing season showed comparable growth to the driest parts of the field. This suggests that giant miscanthus can adapt to varying moisture regimes, but only up to a certain extent.

Deer resistance and its implications for marginal land use

The field in this study was subject to high levels of deer pressure, yet no significant grazing damage was observed on the giant miscanthus plants. This is particularly important in regions like Maryland, where deer pressure can severely damage traditional crops, leading to substantial yield losses. Giant miscanthus, with its fibrous and tough stems, appears to be largely unpalatable to deer. The resilience of giant miscanthus to deer grazing not only reduces the potential for yield loss, but also simplifies management compared to more vulnerable crops. This attribute makes giant miscanthus a valuable crop potential crop for farmers dealing with increased wildlife management challenges, further supporting its potential as a sustainable alternative for marginal lands.

Challenges and considerations for future adoption

Despite promising research results on the ability of giant miscanthus to grow in marginal fields, several challenges remain for the widespread adoption of giant miscanthus on marginal lands. One of the primary barriers is the high initial investment required for planting, including the cost of rhizomes and specialized planting equipment which is estimated to be $1000 per acre (Jacobson, 2024). Although the crop is low maintenance once established, these initial costs can deter farmers from adopting miscanthus without assurance of long-term viability. Additionally, the crop's yield on marginal land, although promising, is not on par with yields from prime agricultural land. There is also a need for a reliable market for giant miscanthus, especially in areas where yield potential is lower. Further efforts should focus on market development and cost-sharing initiatives to facilitate the adoption of this crop.

Future research directions

Future research should focus on refining the management practices for growing giant miscanthus on marginal lands. This includes examining the optimal soil sodium thresholds for giant miscanthus growth, as well as identifying the best strategies for managing waterlogging in areas prone to flooding. Long-term studies should also be conducted to evaluate the sustainability of giant miscanthus cultivation, including its impact on soil health, carbon sequestration, and overall farm profitability. Additionally, exploring the economic viability of giant miscanthus in the context of diverse local markets is crucial for determining its long-term success as an alternative crop for marginal lands. By addressing these gaps in knowledge, giant miscanthus could become a more widely adopted solution for farmers dealing with challenging environmental conditions.

Conclusions

This study demonstrates that giant miscanthus (*Miscanthus × giganteus*) has significant potential as an alternative crop for marginal lands on the Eastern Shore of Maryland. The crop successfully grew under challenging conditions, including saltwater intrusion, waterlogging, and high deer pressure, with yields of 2.8 tons per acre in the first year and 4.8 tons per acre in the second year. Giant miscanthus showed resilience to moderate soil sodium levels and resistance to deer browsing, making it a promising option for revitalizing marginal farmland. While challenges remain, such as yield differences compared to prime land and market development, giant miscanthus production offers a promising opportunity for farmers facing environmental stressors.

Acknowledgments

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