Laidlaw Leadership and Research Scholars program

Summer (I) Research Paper

Leveraging Organic Underutilized Resources and Urine-Based Fertigation for Sustainable Urban and Peri-Urban Crop Production

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Abstract

This research delves into the utilization of raised bed gardening as a strategy for urban and peri-urban crop cultivation, with a focus on leveraging Organic Underutilized Resources (OURs). We conducted the experiment in the summer of 2023 in a high tunnel using kale as a bioassay at Dilmun Hill Student Farm, at Cornell University, Ithaca, New York. Using a total of seventy-two, 30-gallon sacks, we compared urine versus Miracle-Gro® fertilizer on 4 different substrates: Maize Stover, Maize Stover ± Biochar, Wheat Straw Bales, and Field Soil.

We found that the utilization of urine, a valuable source of nutrients, in combination with crop residues, as a carbon source, positively impacts above-ground biomass across substrates, and hence could be leveraged within the Circular Bionutrient Economy (CBE) framework; to transform organic waste into valuable agricultural inputs (Midega, 2022).

Introduction

The global shift towards urbanization— an increase in the spread of a nation's population living in urban areas —has led to more than half of the world's population residing in urban and peri-urban environments (Satterthwaite et al., 2010, Hume et al., 2021). According to the Food and Agriculture Organization of the United Nations, urban and peri-urban environments are spaces within cities and surrounding regions. Urban and peri-urban agriculture has a crucial role in food and nutrition security in most low and

middle-income countries and it's quite unfortunate that access to land in such contexts is becoming increasingly difficult (Satterthwaite et al., 2010). This trend of urbanization has been encountered with a concerning issue – soil contamination. Even though urban gardens are a potential source of affordable, locally grown, fresh produce, they may also increase exposure to heavy metals and toxic chemicals such as lead and other heavy metals present in the urban environment (Mitchell et al., 2014). Therefore, there is a need for innovative solutions to enable sustainable crop production, especially in such environments. Gardening in raised beds is encouraged among urban gardeners to help reduce exposure to soil contaminants (Mitchell et al., 2014). For example, in the Kibera slums of Nairobi, Kenya, sack gardening - a practice where growers plant vegetables into the sides and on top of growing media contained in sacks - has become more acclaimed (Gallaher et al., 2015)

In this paper, I focus on the application of organic underutilized resources; with a specific emphasis on maize stover(chopped-up maize stalks), and wheat straw, as well as the innovative use of urine as a key nutrient source to support the growth of kale on multiple substrates, including field soil. The growing need for the use of organic amendments, and alternative, low-cost effective fertilizer substitutes positions urine-based fertigation systems as a potential substitute for industrial, synthetic fertilizers (Ranasinghe et al., 2016). Human urine contains plenty of plant-available nitrogen (N), phosphorous (P), and potassium (K), with a fertilizer value of N/P/K 18:2:5, which can be leveraged to address soil nutrient deficiencies (Krounbi et al., 2018, Pradhan et al., 2007).

Specifically, we explored the formulation of urine-fertilized raised bed media systems to enhance vegetable crop production in urban and peri-urban areas within the CBE framework.

The main objective of this study was to evaluate and compare the use of urine as a fertilizer versus conventional synthetic fertilizer (Miracle-Gro®) on plant growth and biomass of kale plants grown in four raised-bed substrates: field soil, maize stover ± biochar, and wheat straw.

Methods

This field experiment was conducted in the summer of 2023 in a high tunnel using kale as a bioassay at Dilmun Hill Student Farm, at Cornell University, Ithaca, New York. Using a total of seventy-two, 30-gallon sacks, experimental units were laid out in a completely randomized design with at least four replicates per treatment to compare urine versus Miracle-Gro® fertilizer on 4 different substrates: Maize Stover, Maize Stover ± Biochar, Wheat Straw Bales, and Field Soil.

Non-soil (organic underutilized resources) experimental units underwent initial conditioning with full-strength urine and concentrated Miracle-Gro® for one month, then two four-week-old dinosour kale plants (cultivar Black Mamba) were transplanted into each unit.

Units were fertigated once every week: urine at a rate of ⅛ dilution with water and Miracle-Gro® mixed at the standard rate (24-8-16).

Throughout the growing season, plant health (on a qualitative 0-3 scale) and leaf length were measured at multiple time points. Wet and dry biomass were also measured at the end of the season.

Results

The results obtained from plant health and biomass measurements revealed promising findings. Although the growth rate of Miracle-Gro® fertilized experiment units was slightly better than that of urine within the soil treatment, urine-fertilized units exhibited comparable performance to Miracle-Gro® in both maize stover (with and without biochar) treatments, in terms of promoting plant growth and development. Notably, urine-fertilized media containing field soil, and maize stover ± biochar substrates displayed remarkable plant biomass, suggesting their potential as effective components in soil media formulations for urban and peri-urban crop production. Virgin wheat, however, performed much more poorly than the other treatment

groups, emphasizing the importance of fertilizer-substrate interactions and the need for tailored approaches depending on the substrate and fertilizer used (Fig. 1).

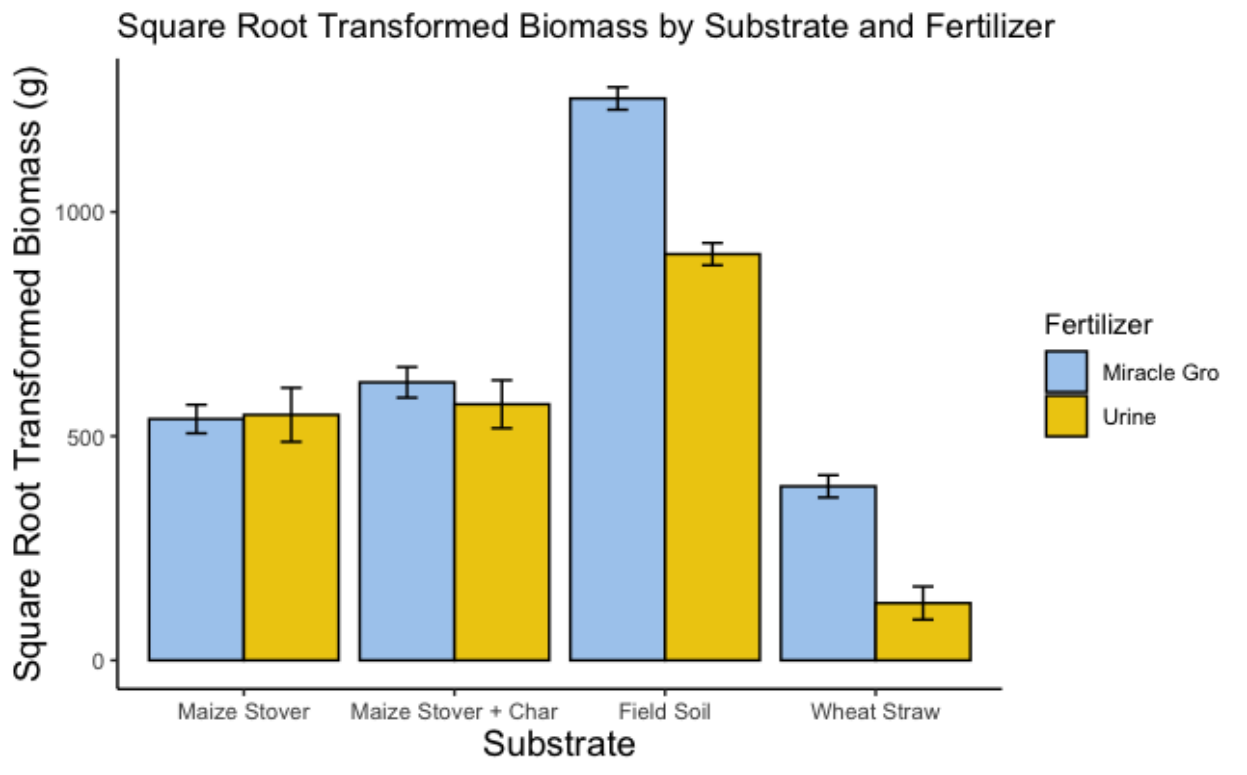

Figure 1. Above-ground biomass by substate for urine and the Synthetic fertilizer Miracle-Gro®. We found that kale grown in soil and wheat straw had greater above-ground biomass when treated with Miracle-Gro®. However, kale grown in corn stover and corn stover with char has no significant difference in above-ground biomass to that treated with Miracle-Gro®.

Discussion

The findings of this research emphasize the viability of urine as a valuable source of nutrients for crop production in urban and peri-urban environments. The success of

urine-fertilized raised bed media, particularly in combination with organic materials such as maize stover ± biochar, indicates the potential to transform waste into a valuable resource.

Moreover, the utilization of urine-based fertigation systems presents a novel approach to efficiently deliver nutrients to crops, thereby contributing to sustainable and resource-efficient agricultural practices.

Conclusion

In conclusion, the utilization of Organic Underutilized Resources and urine-based fertigation systems holds great promise for addressing the challenges posed by soil contamination in urban and peri-urban environments. The research underscores the effectiveness of urine-fertilized raised bed media in supporting crop growth and highlights the significance of appropriate substrate combinations. This study contributes to the growing body of knowledge on sustainable urban agriculture, offering insights into innovative strategies that can enhance food security and mitigate the adverse effects of soil contamination in densely populated regions.

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