EFFECT OF PHOSPHORUS AND POTASSIUM APPLICATION ON THE GROWTH AND YIELD OF A 14-YEAR-OLD MISCANTHUS X GIGANTEUS STAND

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ABSTRACT

Miscanthus x giganteus (miscanthus) is a perennial C4 grass grown for renewable bioenergy and bioproducts. Despite its known low nutrient requirements, the specific fertilization needs of miscanthus remain poorly constrained, especially for older stands. This study aims to guide nutrient management practices for miscanthus by determining the demand for phosphorus (P) and potassium (K) fertilization and identifying the soil testing values at which these nutrients optimize yields. To address this aim, we conducted an experiment in a 14-year-old miscanthus stand in central Iowa, which had no prior fertilization history. The experiment followed a randomized complete block design with four blocks, each containing seven plots (one for each treatment and four controls), each measuring 800 ft². Baseline measurements of soil fertility indicated low soil test values for P (5-13 ppm) and K (73-181 ppm) were common in most plots. Stem height, density, yield and soil testing were also recorded prior to treatment. There were positive correlations between pre-treatment soil nutrient levels and yield, with K showing a slightly stronger relationship than P. Following harvest, treatments of P (100 lb/a), K (130 lb/a), and P+K (100 lb/a P + 130 lb/a K) were applied, with all plots receiving nitrogen (N) at 200 lb/a. Throughout the following growing season (May to October), canopy height, staging, and leaf area index (LAI) were taken. Preliminary results from the season prior to treatment indicate a positive correlation between height and yield that we applied to predict yield in advance of the post-treatment harvest. Averaged predicted yields indicated increases in the control, P, and P+K treatments, with P+K treated plots showing the greatest increase. In contrast, K-treated plots exhibited no yield change. At the end of the growing season, we will measure final stem height, stem density, yield, and soil nutrient levels for comparison with baseline data. This work will enhance our understanding of miscanthus's nutrient requirements, contributing to more informed fertilization recommendations.

INTRODUCTION

Compared to other crops, miscanthus has been shown to have high nutrient uptake and nutrient use efficiency and low nutrient input requirements due to the ability to translocate nutrients to and from its rhizomes (Cadoux et al., 2012). While its nutrient needs are not fully understood, current research suggests that potassium (K) may be of higher importance than phosphorus (P). The significance of K is due to miscanthus requiring a higher concentration of K to maintain optimal growth, a larger percentage of P re-mobilized back to the rhizome by the end of the growing season, and a greater concentration of K removed at harvest (Beale et al., 1997; Himken et al., 1997). The ongoing development of nutrient recommendations is largely driven by the need to offset these nutrient removals, which is to be applied on an annual basis (Cadoux et al., 2012). Even so, yield response to P and K fertilization appear to be dependent on initial soil test values, which are often quite variable, indicating critical soil nutrient values remain unclear (Clifton-Brown et al., 2007; Haines et al., 2014, Shield et al., 2014). Because of the uncertainties in the literature, this study's primary goals are to determine whether P and K fertilization is essential for optimal yields and identify precise soil testing values at which fertilization becomes necessary. In this research, we applied nutrient treatments to a 14-year-old miscanthus stand, including combinations of nitrogen (N), P, and K at rates determined to surpass its needs. This approach ensures plants are not nutrient-limited. The outcomes will contribute to more precise fertilization guidelines, potentially increasing yields and profitability for miscanthus growers. In addition, the findings are a step towards the development of fertilization rate recommendation

MATERIALS AND METHODS

In 2024, an experiment was conducted at Sorenson Farm near Ames, Iowa (42° 0' 43.2504" N, - 93° 44' 40.9092" W) in a 14-year-old stand of sterile, triploid clone *Miscantus x giganteus* (Greef et. Deu. ex. Hodkinson et Revoize; 3n=57) clone "Freedom", provided by AGgrow Tech, High Point NC USA. The soil types included Webster clay loam (Fine-loamy, mixed, superactive, mesic Typic Endoaquolls), Clarion loam (Fine-loamy, mixed, superactive, mesic Typic Hapludolls), and Canisteo clay loam (Fine-loamy, mixed, superactive, calcareous, mesic Typic Endoaquolls). The experiment was set up in a randomized complete block design with four replicates. Each block contained seven plots: one plot each for a P treatment, a K treatment, and a P+K treatment, and four control plots. Each plot measured 800 ft^2. To address pre-existing variability in the stand, this study aimed to ensure a yield response was due to applied fertilizer rather than prior variability. Predicted yields obtained from satellite imagery from the 2021 growing season were used to calculate average yields for each treatment group (Emran et al., in preparation). An ANOVA was then performed to confirm no significant difference among treatments prior to fertilizer application (Excel, Version 16.0.10415.20025, 64-bit, Microsoft Corp.). Fertilizer treatments were broadcast applied on May 3, 2024 for P and K, and on June 4, 2024 for N. The N, P, and K fertilizers were applied as follows: N was applied using polymer-coated sulfur-coated urea (43-0-0) at a rate of 200 lb/a N, applied to all plots; P was applied using triple super phosphate (0-46-0) at a rate of 100 lb/a P; and K was applied as potassium chloride (0-0-62) at a rate of 130 lb/a K.

Baseline measurements for stem height, stem density, and yield were taken in each plot before fertilization at the end of the growing season. Soil cores were collected from each plot at depths of 0-6 inches and 6-12 inches for nutrient analysis. Throughout the growing season following fertilization (May to October), above-ground measurements of canopy height, leaf area index (LAI), and staging were measured two to four times per month. A linear regression model of the relationship between the pre-fertilization stem height and yield, along with this season's maximum canopy height, was applied to predict the current year's yields (R stats package, version 4.4.1). Moving forward, baseline measurements will be remeasured and directly compared to those that were initially taken.

RESULTS AND DISCUSSION

Pre-Fertilization Results

In the top 6 inches of soil, soil test P levels across the 28 plots ranged from 5-13 ppm, with a mean of 8.7 ± 0.5 ppm, while soil test K levels ranged from 73-181 ppm, with a mean of 118.7 ± 5.5 ppm. Slight positive correlations were found between both soil test P and K and yields, suggesting some potential for yield response with increased soil nutrient levels (figure 1). However, the relationships were relatively weak, with R^2 values of 0.14 for P and 0.16 for K, indicating that additional factors likely influence yield. Stem density showed very little correlation with yield, while stem height demonstrated a positive correlation. Therefore, if a yield change is recorded, the response may be primarily in the form of taller plants rather than increased stem density.

Post-Fertilization Results

Using pre-fertilization and predicted post-fertilization yields, we estimated the average relative yield change for each treatment (figure 2). The control plots increased in yields with a relative difference of 7.7%. The P-treated plots exhibited a relative difference of 16.3%, followed by the P+K-treated plots at 18.4%, showing the greatest yield increase. The K-treated plots did not change, indicating that P fertilization may be more critical than K in this stand. This suggests that baseline soil test P levels were insufficient for optimal growth, while K levels were already adequate. Final yield data from the chopper harvest at the end of the season will provide further insights, as a yield response may come in other forms beyond height, such as stem density. Throughout the season, no significant differences were observed in height, staging, or LAI among treatments.

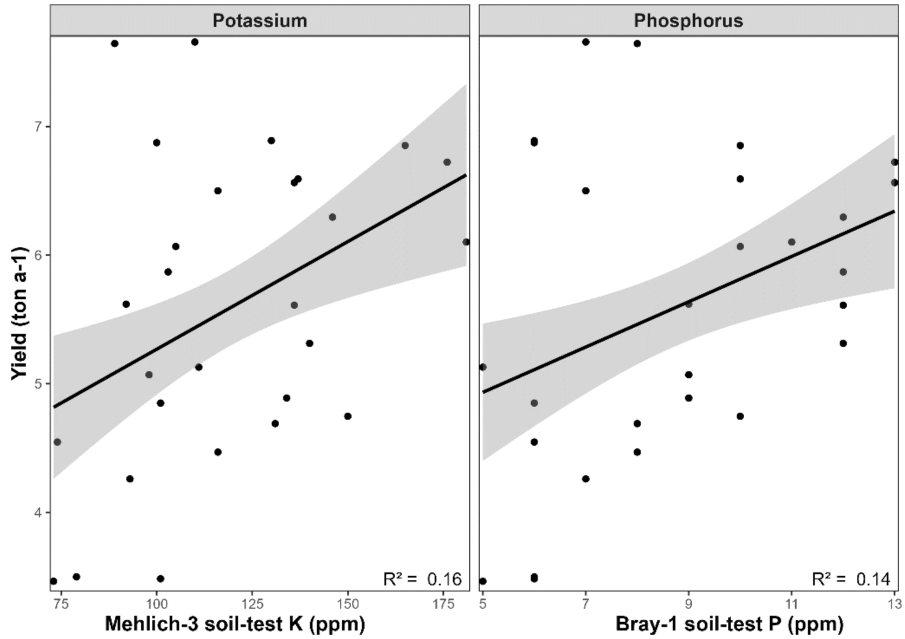

Figure 1. Relationship between 2023 pre-fertilization yield and soil test phosphorus (P) and potassium (K) levels. Miscanthus yield was mechanically harvested in March 2024 and soil was sampled in April 2024.

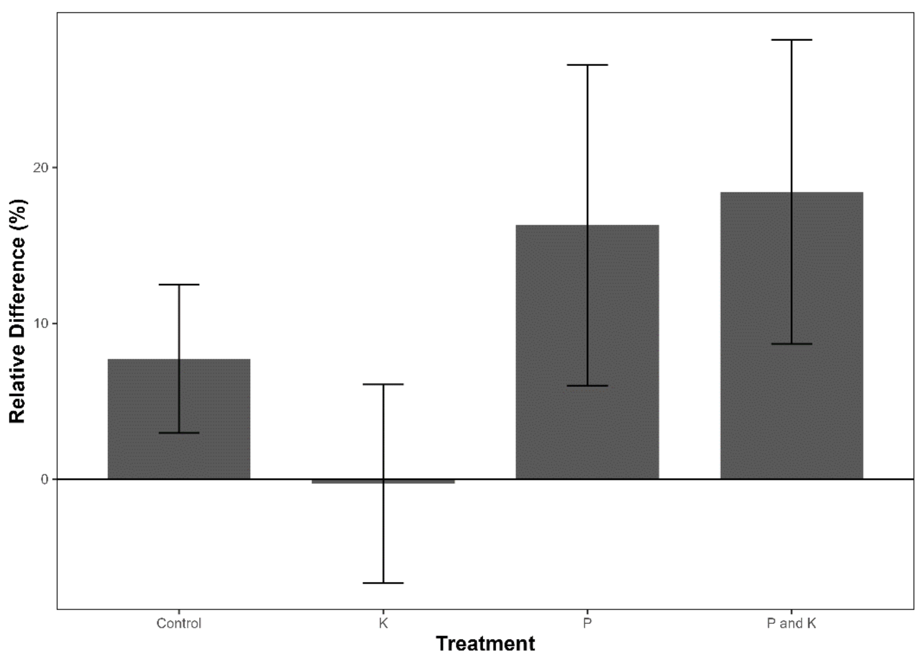

Figure 2. Relative difference (post fertilization minus pre-fertilization) in predicted yields for each treatment. Pre-fertilization yields are from the 2023 mechanical harvest, while 2024 post-fertilization yields are predicted based on heights (see methods). Fertilized plots included P, K, and P+K treatments (n=4 respectively), while unfertilized control plots (n=16) were also analyzed. Error bars indicate standard error.

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