THE EFFECTS OF MANURE APPLICATIONS ON COTTON YIELD AND SOIL GREENHOUSE GAS EMISSIONS IN THE TEXAS HIGH PLAINS

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ABSTRACT

The cost of inorganic fertilizer is continually rising, which has caused an increased interest in alternative solutions. Along with fertilizer prices increasing, carbon emissions are following the same trend. There is an upcoming demand for carbon mitigation/sequestration research. The purpose of this study was to assess the effects of various manure applications on crop growth and greenhouse gas emissions in three different cropping systems in the Texas High Plains. The no-tillage cropping systems consist of wheat cover/continuous cotton, fallow/cotton/wheat, and fallow/wheat/cotton. The treatments utilized in this study included: 1) no fertilizer applied, 2) inorganic fertilizer, 3) composted manure, 4) separated dairy feedlot manure, 5) whole digestate, and 6) commercial raw feedlot manure. Results included the 2023 growing season. Greenhouse gases (CO_2, CH_4, N_2O, NH_3) were measured from the soil surface throughout the season using a multi-gas FTIR analyzer. Results included cotton lint yield and greenhouse gas emissions for CO_2, CH_4, and N_2O that were presented as CO_2 equivalents.

INTRODUCTION

There is a need for alternative fertilizer sources that are both economically and environmentally viable, specifically in a semi-arid climate. The Texas High Plains is a top producing region for cotton (*Gossypium hirsutum*), producing 30 to 35% of the nation's cotton (Bishop, 2023). Fertilizer is an essential economic component for successful yields in cotton production. Manure is more easily accessible and renewable compared to inorganic nitrogen sources. Approximately 16 million acres (8%) of US cropland were fertilized with manure (Havlin, 2016). Along with the use of more renewable fertilizer sources, the environmental effects of that source need to be assessed. The objective of this study was to assess the effect of anaerobic digestate and manure applications on crop growth and soil greenhouse gas emissions. Agricultural practices, such as fertilizer application, release greenhouse gas emissions (GHG) into the atmosphere. The most important greenhouse gases associated with agriculture practices include carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). CO_2 is the most abundant gas in the atmosphere. Agricultural practices are known to cause the increase of carbon dioxide (CO_2) in the atmosphere, contributing to global warming. Because of the semi-arid climate, minimal precipitation and soil erosion are factors that must be considered throughout the growing and nongrowing season. The minimal precipitation and high temperatures can greatly affect the amount of GHGs emitted from the cotton crop. Each GHG is given a global warming potential to compare the amount of energy the emissions of 1 ton of gas will absorb over a given amount of time, compared with the emissions of 1 ton of CO_2. N_2O has a GWP of 265 times that of CO_2. CH_4 has a GWP of 28 times that of CO_2 (EPA, 2023). Increased absorption of energy by greenhouse gases can cause harmful effects for the environment. Utilizing manure as fertilizer sources is a common practice around the world, but the environmental effects of replacing inorganic sources with organic requires more research.

MATERIALS AND METHODS

This study was located at Texas A&M AgriLife Research and Extension Center in Lubbock, TX. The soil series for this study was an Acuff loam. The no-tillage cropping systems consisted of wheat/cotton/cotton, fallow/cotton/wheat, and fallow/wheat/cotton rotations. Wheat was planted on October 27th, 2022. Cotton was planted on May 9th, 2023; Replanted June 7th, 2023. A RCBD arranged as a split-plot was utilized for this study. Each plot was eight rows wide and 40 ft long with four replications. The treatments utilized in this study included: 1) no fertilizer applied, 2) inorganic fertilizer, 3) composted manure, 4) separated dairy feedlot manure, 5) whole digestate, and 6) commercial raw feedlot manure. Both inorganic and organic fertilizer sources were calculated based on a 150lb/A rate for the 1st application and 50lb/A for the 2nd application. For statistical analysis, SAS 9.4 was utilized. Greenhouse gas emissions were measured throughout the season. Sampling times included 1, 3, 7, 10, 14, 21, 28, 35, 49, 56, 63, 70, 77, and 98 days after treatment. Temporal soil samples at 0-6in and 6-12in depths were collected from every plot in the continuous cotton rotation each GHG sampling time.

RESULTS

Results indicated that the inorganic fertilizer treatment presented numerically greater cotton lint yield compared to the other treatments. The increased cotton lint yield presented by the no fertilizer treatment could be a result of residual nutrients found in the preseason soil. From the organic treatments, compost and whole digestate presented greater cotton lint yield compared to separated dairy manure and raw manure treatments. CO_2 equivalent results indicated separated dairy manure had significantly greater CO_2e compared to all other treatments at 35 DAT. At 42 and 98 DAT, no fertilizer and compost had significantly greater CO_2e compared to all other treatments. At 70 and 77 DAT, no fertilizer had significantly greater CO_2e than all other treatments. Overall, results indicated the no fertilizer treatment presented greater CO_2 equivalents compared to all other treatments. Separated dairy manure, raw manure and digestate presented the least CO_2 equivalents compared to all treatments.

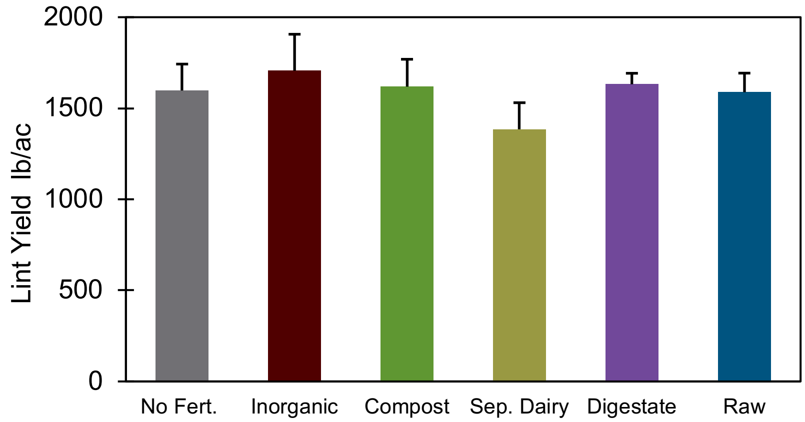

Figure 1. Cotton lint yield (lb/ac) at Lubbock by treatment. Data presented from November 17,2023. No significant differences were found at $p<0.05$.

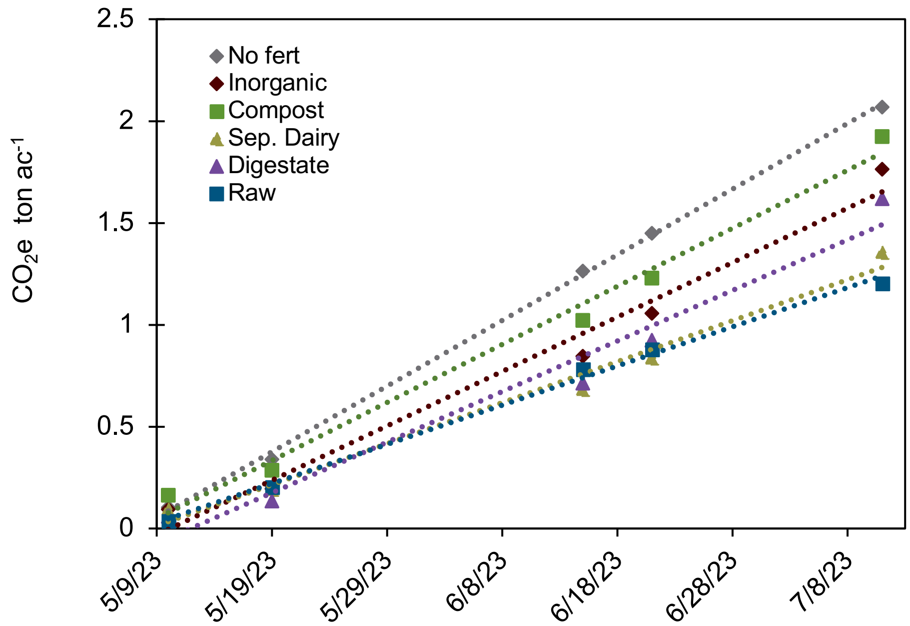

Figure 2. CO_2 equivalents (ton ac^{-1}) at Lubbock by treatment. Data presented from May 10th, May 19th, June 15th, June 21st, and July 11th (35,42,70, 77, and 98 days after 1st application). Wet conditions prevented measurements on 56 and 63 DAT. CO_2 equivalents calculated using CO_2e = [CO2 * 1] + [CH4 * 28] + [N2O * 265]

SUMMARY

With the increase in demand for fertilizer, more renewable and efficient sources need to be supplied. Manure as a fertilizer source has the capability to provide environmental and economic benefits for crop production. The concern for implementing manure as a fertilizer source pertains to its' effect on the environment. Separated dairy manure, digestate, and raw manure as a fertilizer source has potential to reduce carbon dioxide emissions compared to no fertilizer, inorganic fertilizer, and composted manure. Further research is being conducted to assess the environmental impacts of manure sources as fertilizer for multiple growing seasons.

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