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Dynamic Soil Properties in the Lower Rio Grande Valley: Carbon and Nitrogen Responses to Different Tillage Practices

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DYNAMIC SOIL PROPERTIES IN THE LOWER RIO GRANDE VALLEY: CARBON AND NITROGEN RESPONSES TO DIFFERENT TILLAGE PRACTICES

A Thesis

by

LUZYANNET BALLESTEROS GONZALEZ

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ABSTRACT

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There has been increased attention in utilizing agriculture for carbon sequestration. Soil carbon and nitrogen are two dynamic soil properties (DSPs) that are indicators of soil health and function and have overlapping cycles. These soil properties change frequently as a result of environmental conditions and agricultural management practices. This study focuses on the impact of tillage practices in unirrigated agricultural fields in Hidalgo and Willacy counties located in South Texas on Hidalgo Sandy Clay Loam; With a particular focus on Soil Total Carbon (TC), Soil Inorganic Carbon (SIC), Permanganate Oxidizable Carbon (POXC), Carbon and Nitrogen ratio (C:N), Soil Organic Matter (SOM), and Total Nitrogen (TN). The tillage regimes are strip tillage (conservation tillage for 3 to 6 years), intermittent tillage (strip tillage for 2 to 3 years followed by conventional tillage) , and conventional tillage. Two ecological sites (established tree lines that have been undisturbed for at least 50 years) are included as reference points. Results show ecological reference sites on average are significantly higher than those fields under conventional, intermittent and strip tilled for TC, TN, and SOM for the top 0 - 5cm. POXC on ecological reference sites was significantly higher from 0 - 5 cm, 5 - 10 cm, and 30 -50cm. However, when comparing conventional tillage to intermittent and strip there was no statistically significant difference among TC, TN, SOM, POXC, and C:N at all depths. Finally,

most significant differences among the parameters measure could be observe on the top 0 - 10cm with the exception of SIC due to the soil high content of calcium carbonates and POXC in which the ecological reference sites were significantly higher at 30 – 50 cm than conventional sites.

DEDICATION

This research project is dedicated to my parents, Marco A. Ballesteros and Mayra Y. Gonzalez, who are the hardest working people I have ever known and who have showed me to stand up every time I fall. Additionally, I dedicate this to all the people who helped me and encourage me on this journey. It is a rare occurrence that everything aligns to accomplish one's goals, yet that was the case for me. However, it was not just luck but the hard work and resilience of all the people that surrounded me and supported me along this journey.

Este proyecto de investigación está dedicado a mis padres, Marco A. Ballesteros y Mayra Y. González, quienes son las personas más trabajadoras que he conocido y quienes me han enseñado a levantarme cada vez que me caigo. Además, dedico esto a todas las personas que me ayudaron y apoyaron en este camino. Es raro que todo se alinee para lograr los objetivos, pero ese fue mi caso. Sin embargo, no fue solo suerte sino el arduo trabajo y la resiliencia de todas las personas que me rodearon y me apoyaron a lo largo de este viaje.

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A special thank you to all who helped me collect soil samples, sieve, sort, label, shipped, process and so much more – Carlos Garcia Patlan, Temiloluwa Awotoye, Rocio Hernandez, Sarah Godwin, Faeqa Moshin, Jesse Barber, Samikshya Subedi, Michael Navarro, Leonardo Ballesteros Gonzalez, Tom Eubanks, Christopher de la Rosa and Fallon Faustro. One final thank you to Eduardo Villa and Bean for their resilience, support, and love.

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CHAPTER I

INTRODUCTION

Climate change is undeniably caused by anthropogenic emissions directly caused by the burning of fossil fuels, infrastructure development, and agriculture. Recent research estimates that agriculture and land-use change collectively accounted for nearly one-quarter of global greenhouse gas emissions (including carbon dioxide, nitrous oxide, and methane) in 2010 (Raganathan et al., 2018). Numbers are similar in the United States, where agriculture accounts for 11% of greenhouse emissions with crop cultivation accounting for 53.6%, livestock for 40.1%, and fuel combustion for 6.4% (U.S EPA's Inventory of U.S. Greenhouse Gas Emission Sink by State: 1990-2020.) As a result, the agricultural sector is both uniquely positioned and increasingly relevant to reduce global greenhouse emissions in response to growing challenges of anthropogenic induced climate change. Increasing attention and investment has been direct towards “climate-smart agriculture” or also called CSA which are loosely defined as implementation practices that benefits the environment in turn have positive impacts on yields and producer income in the long run (Huang et al, 2018). CSA strategies include a higher efficiency in livestock farming through both management and improved technology to help reduce emissions of nitrous oxide and methane; decreased dependence on fossil-fuels, synthetic fertilizers, and other nonrenewable resources to reduce carbon dioxide and nitrous oxide consumption and emissions; and forestry, agroforestry practices and agricultural soils management to help sequester carbon (CSAF Mitigation List FY2023). Investment in these and other strategies are "significant part of the American climate solution" (Via, 2021) to reduce greenhouse gases, both on-farm and off farm. Within CSFA strategies soil management has been deemed critical in helping reduce emissions of carbon dioxide (Via, 2021). In the United States crop cultivation and fuel combustion account for 60% of emissions (U.S EPA's Inventory of U.S. Greenhouse Gas Emission Sink by State: 1990-2020.) which can be closely linked to on-farm practices such as tilling and other soil disturbances, as well as to the use of heavy machinery in both on farm and off farm related activities (Lal, 2015).

Tillage is the agricultural preparation of soil by physical disturbance, often deployed to manage or remove existing vegetation or other plants that might compete with a more desired crop, or to prepare soils for targeted planting; Early examples of tillage included basic human-powered methods using basic hand tools including smattocks, picks, and hoes (Lal, 2015). Around 3000 BC, domesticated draft-animals were used to pull wooden implements including ploughs, rollers, and other machineries to disturb, cultivate, harrow, or mulch a field (Britannica, 2008). The 1940's and 1950s marked a new age of agriculture where technology allowed for the use of tractors and other large machines to help do this work more quickly and at larger scales (Olmstead & Rhode, 2001). Still, the use of tilling follows the same basic approach, and in its many forms include some sort of agitation and disturbance of topsoil. With a growing understanding of both the science of tilling and its implications, we know that intensive soil agitation ultimately deteriorates soil structure and increases the loss of carbon (Jacinthe P.-A, 2005; Zibilske, 2007; Jemain, 2013). Tillage physically breaks up chunks of soil bound together with other nearby particles (known as soil aggregates) in response to many factors including activity of microorganisms including earthworms, fungal hyphae, and bacteria (Via, 2021; Anguelov et al., 2020) . Tillage not only disrupts the activities of these microorganisms, but also exposes organic carbon in the soils to oxygen, increasing the rate of consumption by other microbes that naturally release CO_2 into the atmosphere (Stika, 2016; Iowa Lit Foundation, 2015; Via, 2021;). Unlike non-disturb locations like forest or tree lines, agricultural systems do not accumulate organic matter (leaf litter) and tend to lose carbon from the disturbance and lack of addition of biomass (Hussain et al., 2019). Moreover, the physical disturbance and degradation of soil aggregates increases the potential for carbon-rich top-soil to be eroded by wind and water (Vita, 2021; Lal, 2015; Anguelov et al., 2020).

To help mitigate carbon dioxide emissions, CSA practices are now being widely promoted. Techniques such as reduced tillage (including no-till practices), cover crops, agroforestry, and other modes to conserve or regenerate plant biomass and other residues to the soils have been recently featured by the USDA's program Climate-Smart Commodities Program, which has invested more than 2.6B US$ to these and other similar approaches. These programs have a key assumption that properly managed agricultural lands can help sequester significant amounts of carbon dioxide. According to Via (2021) the earth's soil can store half the amount of carbon found in the atmosphere, if properly managed in ways that benefit farmers and the environment. Additionally, Abdalla et al. (2016) meta-analysis found that on average tilled soils emitted 21% more carbon dioxide than untilled soils. The amount of carbon stored in soils, however, ultimately depends on a number of factors, including the inherent soil properties, climate patterns and weather events, as well as short- and long-term management (Lal, 2015, 2016; Huang, 2018). For example, in the study conducted by Potter et al. (1998) across Texas, he concluded that soil organic carbon decreased with an increase in mean annual temperature. According to the USDA-Natural Resources Conservation Service, (USDA-NRCS), management systems with the healthiest soils and the best potential for climate smart outcomes include the four Soil Health Principles: reduced disturbance, keep the soil covered all or most of the year, maintenance of living roots, and increased plant diversity; Soil health is defined by USDA NRCS as “the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans”. In cropland soils, these principles often included no-till or conservation tillage to reduce disturbance, keep the soil cover, and maintain living roots to enhance soil health and in return improve soil properties associated with improved yields (Huang et al. 2018; Via, 2021). However, each agricultural operation is uniquely managed by the producer and factors like irrigation management, crop rotations, fertilizer inputs, fungicides, pesticides, and other agronomic considerations vary when deciding the best approach in each given situation. In addition, soil texture, pH, temperature might also affect the degree of CO_2 sequestration in croplands (Potter et al., 2018). Finally, current methodology of measuring soil carbon and soil sampling could also play a role in the changes that can be observed and study for short-term implementation studies like this one, as Via (2021) & Caudle (2020) mentioned there is difficulty in measuring and estimating small changes in soil carbon. This means that singling out the response of carbon to conservation practices and excluding other more dynamic parameters might be insufficient in determining if one - the soil is “healthy” and two – if adopting conservation practices like strip tilled for short periods of time have a significant impact in soil carbon and nitrogen.

Conservation Tillage in the Rio Grande Valley , Texas

The lower Rio Grande Valley (RGV) is located in South Texas, and it is composed by the following southmost counties: Willacy, Cameron, Hidalgo, and Starr. The climate in the region is subtropical with mild winter temperatures rarely below freezing and extremely hot summers.

The region receives an average of 16” to 28” depending on the proximity to the Gulf of Mexico. In the RGV, tillage is an extremely common practice used to manage weeds year-round due to lack of winter, and it is often used strategically and in combination with herbicides. Across the RGV dry land farms are affected by drought and conservation tillage could help in conserving soil moisture due to increase coverage and decrease soil temperature during the hot season (Ogieriakhi & Woodward, 2022). However, conservation tillage adoption is low, from the 5,550 total number of farms in the region, only about 3.3 have adopted any form of conservation tillage (NASS, 2017), which include strip tillage and other reduced tillage practices. The conflict between agronomic concerns of reducing competition from weeds and threatening limited soil moisture can be seen in the low adoptions.

In the past decade, there has been a growing interest in South Texas in conservation strategies that aim to reduce cost, improve returns, and increase resilience to changing climates and markets. For example, within a four-year period from 2013-2016, the number of certified organic farms in south Texas increased five-fold, vaulting Hidalgo (largest county in the RGV) as the county with the highest number of organic farms/farm operations in the state of Texas (Morris & Maggiani 2016). Many of these farms are looking for options to improve soil health, fertility, and pest management, that comply with certified organic standards. Moreover, in the past couple of years farmers have seen a precipitous increase in the prices of herbicide and fertilizers as a result of supply chain issues related to the COVID-19 pandemic, making other options (including other climate smart practices) more economically feasible or rational. Finally, a small, but growing segment of farmers are interested in options such as conservation tillage due to prolonged drought periods followed by floods, input cost increase, new carbon capture markets, and a growing interest in and understanding of soil health.

For this study we partnered with a local commodity producer who manages more than 12,000 acres. His operation has been in his family for generations and managed conventionally; by conventionally we refer to the addition of heavy input utilization and highly mechanization (Sumberg and Giller, 2022). However, as a response to environmental and market stressors he is currently trying soil conservation methods like cover cropping and utilizing conservation tillage. Conservation tillage is a terminology used for various forms of tillage that lowers the physical disturbance and leaves a greater amount of residue behind, however it is still a confusing term for both researchers and producers (Reicosky, 2015). In this study we focused on three different tillage regimes, two of which we considered to be conservation tillage (Strip-tillage and intermittent tillage) since 30 percent or more of the soil surface had remaining crop residue at some point (Anguelov et al., 2020; Conservation Technology Center, 2002):

Conventional Tillage – Conventional Tillage is the intensive manipulation of soil physical properties to control weeds and monocrop for production efficiency (Sumberg & Giller, 2022). Fields under conventional tillage are those that are regularly tilled, and less than 30% crop residue is left behind. For this study tillage disturbs the soil up to six inches (about fifteen centimeters) in depth.

Strip Tillage – Strip tillage is a form of conservation tillage where only a narrow strip is disturbed and opened to deposit seeds and in a way combining the benefits of both no-till and conventional tilled (Ogieriakhi & Woodward, 2022). The residue left behind can help as protection against soil erosion and moisture losses by preventing soil warming and possible water evaporation (Leskovar et al., 2016; Via, 2021; Ogieriakhi & Woodward, 2022).

Additionally prior research done in South Texas showed that strip till is a recommended alternative to conventional tillage as it can potentially increase farmers profitability (Leskovar et al., 2016). In this study fields under strip tillage are those were only rows of nine inches (about twenty-three centimeters) get tilled and the other 30 inches (about 76 centimeters) are left intact, the tilled vs untilled rows are always the same. This means that 25% is tilled and 75% is untilled, therefore it can be considered a form of conservation tillage. The fields sampled for this study have been under this tillage regime under three to six years.

Intermittent Tillage – Fields under intermittent are those that were under strip tillage for a period of time and then had to be conventionally tilled again due to weed pressure. The fields sampled for this study had been under stripped tillage for a period of two to three years and were sampled right after being converted back to conventional tillage.

Dynamic Soil Properties : The Carbon and Nitrogen Dilemma

Dynamic soil properties (DSPs) change with natural and anthropogenic stressors and serve as indicators for soil functions (Potter et al. 1998). DSPs can be separated into three classes of soil properties: chemistry, physics, and biology (Stika, 2016). For this research carbon, nitrogen, soil organic matter content, fall on the chemistry class of DSPs and were observed. Understanding response to management and accurately testing for DSPs, such as soil carbon, in the Lower Rio Grande Valley can support the area's efforts in adopting conservation practices and lessen dependence on synthetic inputs.

Functioning soils provide crucial ecosystem services that can be divided into four categories: provisioning, regulating, cultural, and supporting services (Adhikari and Hartemink, 2015). This soil ecosystem services depend on soil properties and their interaction such as carbon an nitrogen; for example the decline in soil carbon can affect soil functions by affect soil aggregates (Via, 2021) and in return imped soil to provide the desire ecosystem services (Adhikari and Hartemink, 2015).

Carbon and Nitrogen are crucial in plant development and are found in soil in different forms. Each have their corresponding cycles that are inherently tied to ecosystem functions as well as provide ecosystem services. While Carbon and Nitrogen are commonly added to crops to maximize yields in the form of chemical fertilizers and/or mulch which makes the top (0 - 5cm) of soil they can be found in different quantities and forms within different depths of the soil profile (Lv, 2023) as they are driven by distinct microbial groups (Kramer & Gleixner, 2008). Additionally, different forms of these two elements are processed and tested using varying methodologies, equipment, and models (Thoumazea et al., 2020).

Carbon Cycles

Carbon is the building block of life on Earth and flows in different forms across various reservoirs (Reibeek, 2011). One of these reservoirs is soil which is in between the biosphere and the lithosphere and therefore the in between of the fast and slow carbon cycles (Reibeek, 2011). This makes agricultural soils a promising carbon sink when managed correctly. Though the exact management recommendations vary by climate, crop, and inherent soil properties, it is widely accepted that following the USDA NRCS five soil health principles in an agricultural setting can help increase and maintain carbon in soil. However, there are different ways carbon can be found in soil:

Soil Organic Matter (SOM) – SOM three principal components are animal residues and living microbial biomass, active and labile SOM, and stable SOM (Lal, 2016). Stable SOM is the humus or also called the soil organic carbon. SOM is highly valued as it is understood to be the "heart of the soil" and attributes 90% of soil functions (Stika, 2016).

Soil Organic Carbon (SOC) – SOC is comprised of plant and animal decays, microbial biomass, and microbial biproducts; In addition, it comprises 45-60% of Soil organic matter (SOM) (Lal, 2016). SOC plays an important role in soil health and its quantity affects soil structure and aggregation in turn affecting soil functions (Lal, 2014, 2016).

Soil Inorganic Carbon (SIC) – SIC is comprised of dissolved bicarbonates (HCO_3^-) and solid carbonates ($CO_3{}^{2}$), it is the dominant form of Carbon in arid and semi-arid soils (Lal , 2016). The solid carbonates can be then separated into the following pools: Geogenic carbonates (GC), Biogenic carbonates (BC), and Pedogenic carbonates (PC) (Zamanian et al, 2016). While to some extent the following pools are directly inherited from the soil parent material the formation of pedogenic carbonates leads to sequestration of atmospheric CO_2 (Lal, 2016). This carbon sequestration happens from the reaction of carbonates and bicarbonates with Ca^{+2} and Mg^{+2} forming pedogenic carbonates like $CaCO_3$. (Lal, 2016).

Total Carbon (TC) – TC is both SOC and SIC combined (Nelson & Summers, 1996). This means that when looking at TC as a soil health indicator at various depths the parent material of the soil show be consider, as calcareous so

Nitrogen Cycle:

Nitrogen is an essential component of proteins and nucleic acids most abundantly found in gaseous form (N_2) (Britannica, 2021). It is made available to plants through nitrogen fixation by rhizobia and other microorganisms living in symbiosis with roots of certain plants and through electrical discharges such as lighting (Hafifi, 2014). Most natural fixed nitrogen is bound up in soil organic matter and released by microbial consumption while nitrogen fertilizer is made from the fixation of ammonia using the Haber-Bosch process (NRCS, 2006). Having this in mind there is potential that conservation tillage can increase soil nitrogen as it increases soil organic matter (Reeves et al. 1997), however that increase in nitrogen might be more tightly associated with crop rotation (Tu et al., 2021).

Soil Organic Nitrogen (SON) – SON is found in soil organic material in the form of nitrogen rich compounds including amino acids, nucleic acids, and proteins, in turn organic nitrogen is largely unavailable to growing plants (Walworth, 2013). As organisms decompose organic material, excess nitrogen may be converted into nitrite (Walworth, 2013). In natural undisturbed ecosystems plants utilize both forms of nitrogen and if needed the organic form can supplement the plant's nitrogen demand (Paungfoo-Lonhienne, 2008).

Soil Inorganic Nitrogen (SIN) – SIN includes ammonium (NH_{4+}), nitrate (NO_3^-), nitrite (NO_2^-) with ammonia and nitrate making being the most available form for plant growth (Walworth, 2013). Synthetic nitrogen fertilizer is added to soil as NH_{4+} and when in the presence of oxygen, it is rapidly converted to nitrate. Nitrate is highly soluble and can be easily leached through soil and further undergo the process of denitrification, which reduces nitrate to nitrous oxide (N2O) or dinitrogen (N2) gas by anaerobic bacteria (Walworth, 2013).

Total Nitrogen (TN) – TN is both SIN and SON combined.

Carbon & Nitrogen Ratio(C:N) – C:N is important in managing inputs such as residue for proper nutrient cycling. According to USDA NRCS (2011) a C:N ratio of 24:1 in materials added to the soil is ideal to support soil microorganisms. In contrast a ratio higher than that of 25:1 can immobilize nitrogen (Anguelov et al., 2020; USDA NRCS, 2011). Additionally, the C:N ratio provides insight about the microbial population present with higher ratios correlating to higher fungi : bacterial ratios (USDA NRCS, 2011).

Soil Carbon & Nitrogen Impacted by Tillage

Decisions around tillage frequency and intensity are all factors that affect the rate of carbon emissions. Conservation tillage practices may lead to higher accumulations of soil organic matter in the surface (0-10 cm) for fields that have been longer under conservation tillage (Cooper et al., 2020; Huang et al., 2018; Zibilske & Bradford, 2007; Puget & Lal, 2005; Lopez-Garrido et al., 2014). Previous research on Hidalgo Sandy Clay Loam in Weslaco, TX showed that conservation tillage for 8 years resulted in moderate increase in soil organic carbon in the top four centimeters of soil, and increase in concentrations of soil organic nitrogen at the surface (Zibilske, 2002). On continuous no till fields for over 10 years, total carbon, total nitrogen, organic matter, and active organic carbon increased for a 0 - 30 cm depth with the duration of no till (Islam, 2014). Fields under conventional tillage experience up to 10% losses in organic matter during the first four years (Rhoton, 2000). The physical disruption that conventional tillage causes on soil results in organic matter being consumed faster than it is accumulated (Stika, 2016), which is then exacerbated by semi-arid conditions (Potter et al., 1998). Strip tillage would then leave enough surface residue as well as inject oxygen to the soil for better decomposition and increase in soil organic carbon (Leskovar et al., 2016). However, it is important to note that because of semi-arid conditions in the RGV and short-term length adoption (less than 5 years) conservation tillage practices might have modest improvements in soil organic matter, soil organic carbon, and soil organic nitrogen when use in isolation (Potter et al., 2018; Zibilske, 2002). Regardless, conservation tillage could lead to reduction of CO_2 in the atmosphere (Lopez-Garrido, 2014; Lal, 2015)

CHAPTER II

RESPONSE OF SOIL TOTAL CARBON, INORGANIC CARBON, TOTAL NITROGEN, PERMANGANENT OXIDAZABLE CARBON AND SOIL ORGANIC MATTER IN DIFFERENT TILLAGE REGIMES

Abstract

There has been increased attention in utilizing agriculture for carbon sequestration. Soil carbon and nitrogen are two dynamic soil properties (DSPs) that are indicators of soil health and function and have overlapping cycles. These soil properties change frequently as a result of environmental condition and agricultural management practices. This study focuses on the impact of tillage practices in unirrigated agricultural fields in Hidalgo and Willacy counties located in South Texas on Hidalgo Sandy Clay Loam; With a particular focus on Soil Total Carbon (TC), Soil Inorganic Carbon (SIC), Permanganate Oxidizable Carbon (POXC), Carbon and Nitrogen ratio (C:N), Soil Organic Matter (SOM), and Total Nitrogen (TN). The tillage regimes are strip tillage (conservation tillage for 3 to 6 years), intermittent tillage (strip tillage for 2 to 3 years followed by conventional tillage) , and conventional tillage. Two ecological sites (established tree lines that have been undisturbed for at least 50 years) are included as reference points. Results show ecological reference sites on average are significantly higher than those fields under conventional, intermittent and strip tilled for TC, TN, and SOM for the top 0 – 5 cm. POXC on ecological reference sites was significantly higher from 0 – 5 cm, 5 – 10 cm, and 30 – 50 cm. However, when comparing conventional tillage to intermittent and strip there was no

statistically significant difference among TC, TN, SOM, POXC, and C:N at all depths. Finally, most significant differences among the parameters measure could be observe on the top 0 - 10 cm except for SIC due to the regions soil high content of calcium carbonates, and POXC which showed that the ecological reference sites where higher at 30 – 50 cm. Understanding the response that soil organic matter and soil carbon and nitrogen have when fields undergo conservation tillage in on otherwise conventional agro ecosystem is important for setting realistic expectations for local producers on the increase of such. In addition, it supports the effort in implementation of complementary conservation practices in conjunction with conservation tillage as more dynamic indicators like POXC shows a significant difference between conventional and reference past 0-10cm in contrast to other indicators.

Introduction

In the Rio Grande Valley (RGV) implementation of conservation practices such as conservation tillage is low due to weed and pest pressure exasperated by sub-tropical conditions; from the 5,550 total number of farms in the region, only about 3.3% have adopted any form of conservation tillage (NASS, 2017). However, across the RGV dry land farms are affected by drought due to regions hot climate exasperated by climate change, and conservation tillage could help in conserving soil moisture due to increase coverage and decrease soil temperature during the hot season (Ogieriakhi & Woodward, 2022). Prolonged drought periods followed by floods, input cost increase, new carbon capture markets, and a growing interest in and understanding of soil health has increase the interests of a small, but growing segment of farmers in the RGV.

Tillage is the agricultural preparation of soil by physical disturbance, often deployed to manage or remove existing vegetation or other plants that might compete with a more desired crop, or to prepare soils for targeted planting. It is a common practice across the RGV to combat herbicide resistant weeds, which are exasperated by the lack of freezing winter temperature. With a growing understanding of both the science of tilling and its implications, we know that intensive soil agitation ultimately deteriorates soil structure and increases the loss of carbon (Jacinthe P.-A, 2005; Zibilske, 2007; Jemain, 2013). Tillage physically breaks up chunks of soil bound together with other nearby particles (known as soil aggregates) in response to many factors including activity of microorganisms including earthworms, fungal hyphae, and bacteria (Via, 2021; Anguelov et al., 2020) . Tillage not only disrupts the activities of these microorganisms, but also exposes organic carbon in the soils to oxygen, increasing the rate of consumption by other microbes that naturally release CO_2 into the atmosphere (Stika, 2016; Iowa Lit Foundation, 2015; Via, 2021;). Unlike non-disturb locations like forest or tree lines, agricultural systems do not accumulate organic matter (leaf litter) and tend to lose carbon from the disturbance and lack of addition of biomass (Hussain et al., 2019). Moreover, the physical disturbance and degradation of soil aggregates increases the potential for carbon-rich top-soil to be eroded by wind and water (Vita, 2021; Lal, 2015; Anguelov et al. et al., 2020).

Decisions around tillage frequency and intensity are all factors that affect the rate of carbon emissions. Conservation tillage practices may lead to higher accumulations of soil organic matter in the surface (0 - 10 cm) for fields that have been longer under conservation tillage (Cooper et al., 2020; Huang et al., 2018; Zibilske & Bradford, 2007; Puget & Lal, 2005). Previous research on Hidalgo Sandy Clay Loam in Weslaco, TX showed that conservation tillage for 8 years resulted in moderate increase in soil organic carbon in the top four centimeters of soil and increase in concentrations of soil organic nitrogen at the surface (Zibilske, 2002). On continuous no till fields for over 10 years, total carbon, total nitrogen, organic matter, and active organic carbon increased for a 0 - 30cm depth with the duration of no till (Islam, 2014). Fields under conventional tillage experience up to 10% losses in organic matter during the first four years (Rhoton, 2000). The physical disruption that conventional tillage causes on soil results in organic matter being consumed faster than it is accumulated (Stika, 2016), which is then exacerbated by semi-arid conditions (Potter et al., 1998). Strip tillage would then leave enough surface residue as well as inject oxygen to the soil for better decomposition and increase in soil organic carbon (Leskovar et al., 2016). However, it is important to note that because of semi-arid conditions in the RGV and short-term length adoption (less than 5 years) conservation tillage practices might have modest improvements in soil organic matter, soil organic carbon, and soil organic nitrogen when use in isolation (Potter et al., 2018; Zibilske, 2002).

For this research three different tillage regimes were observed: conventional, intermittent, strip tilled, and two ecological reference sites. The sites with lower disturbance (strip tilled, ecological references) were expected to have significant higher quantities of SOM, SOC, POXC, C:N as compared to the conventional tilled and intermittent fields. As prior research done in the region showed that less tillage for extended periods of time modestly increase SOC in the surface (0 - 5 cm) (Potter et al. 1998; Zibilske & Bradford 2007; Zibilske et al. 2002). Additional research conducted in arid regions also suggests that less disturbance through conservation tillage (no-till) adoption for 3 to 7 years moderately increases SOM, SOC, and TC (Jamei et al. 2013; Ligang et al. 2022). No significant differences were expected past 30 cm in response to management practice as prior research suggests most significant differences in SOM, SOC, and TC between systems occurred in the 0 - 10cm depth (Caudle, 2020; Morrow et al. 2016; Parajuli et al. 2020; Gonzalez-Prieto et al., 2013). Additionally, the equipment used to till the soil in this research disturbs the soil at a depth of about 15 cm, and continuous tillage has been documented to cause compaction (hard pans) therefore anything below would not show a significant difference in response to management practice (Strickler, 2018; Via, 2020). We expect to obtain more knowledge about the changes in various forms of soil carbon (total carbon, inorganic carbon, active carbon) , total nitrogen, and soil organic matter as a result of different tillage regimes short term implementation in the Hidalgo Sandy Clay Loam series and understand to what extent are changes in soil carbon, nitrogen, and organic matter happening at six different depths.

Study Site

The lower Rio Grande Valley (RGV) is located in South Texas, and it is composed by the following southmost counties: Willacy, Cameron, Hidalgo, and Starr (Figure 1). The climate in the region is subtropical with mild winter temperatures rarely below freezing and extremely hot summers; USDA hardiness zone 9b (25 to 30 F) for Starr, Hidalgo, and part of Cameron and Willacy Co; USDA hardiness zone 10a (30 to 35 F) for part of Cameron and Willacy Co. The region receives an average of 16” to 28” depending on the proximity to the Gulf of Mexico, and the soils are moderately permeable and form calcareous loamy sediments according to USDA Web soil Survey. Additionally, for this study we partnered with a local commodity producer who manages more than 12,000 acres. His operation has been in his family for generations and managed conventionally; by conventionally we refer to the addition of heavy input utilization and highly mechanization to maximize production (Sumberg and Giller, 2022).

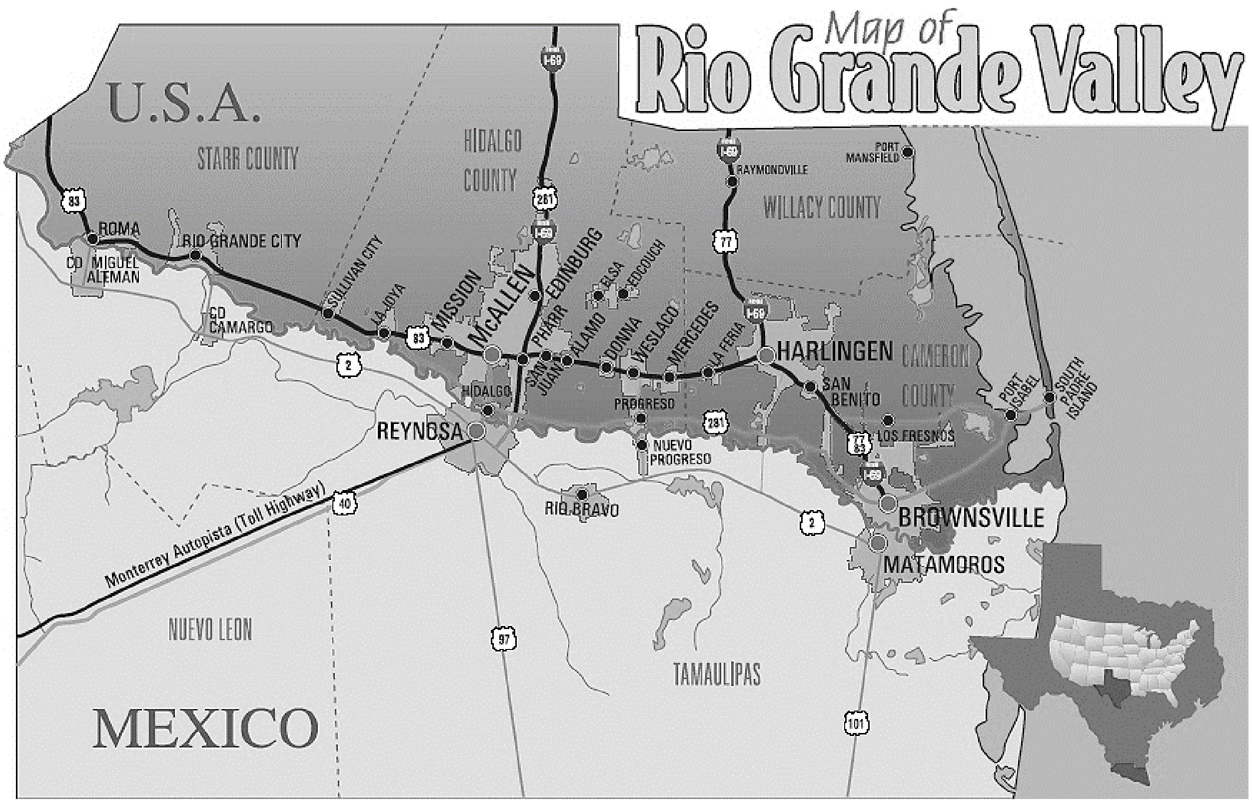

Figure 1 Map of the Rio Grande Valley, Texas. From the University of Arizona by Richard Clift (2013).

Tillage Regimes

In this study we focused on three different tillage regimes, two of which we considered to be conservation tillage since 30 percent or more of the soil surface had remaining crop residue (Anguelov et al. et al., 2020; Conservation Technology Center, 2002):

Conventional Tillage – Conventional Tillage is the intensive manipulation of soil physical properties to control weeds and monocrop for production efficiency (Sumberg & Giller, 2022). Fields under conventional tillage are those that are regularly tilled, and less than 30 crop residue is left behind. For this study tillage disturbs the soil up to six inches (about fifteen centimeters) in depth. The fields sampled for this study have been under this tillage regime for over ten years.

Strip Tillage – Strip tillage is a form of conservation tillage where only a narrow strip is disturbed and opened to deposit seeds and in a way combining the benefits of both no-till and conventional tilled (Ogieriakhi & Woodward, 2022). The residue left behind can help as protection against soil erosion and moisture losses by preventing soil warming and possible water evaporation (Leskovar et al., 2016; Via, 2021; Ogieriakhi & Woodward, 2022). Additionally prior research done in South Texas showed that strip till is a recommended alternative to conventional tillage as it can potentially increase farmers profitability (Leskovar et al., 2016). In this study fields under strip tillage are those were only rows of nine inches (about twenty-three centimeters) get tilled and the other 30 inches (about 76 centimeters) are left intact, the tilled vs untilled rows are always the same. This means that 25 is tilled and is untilled, therefore it can be considered a form of conservation tillage. The fields sampled for this study have been under this tillage regime for three to six years.

Intermittent Tillage – Intermittent tillage for this study is considered a form of conservation tillage. Fields under intermittent are those that were under strip tillage for a period of time and then had to be conventionally tilled again due to weed pressure. The fields sampled for this study had been under stripped tillage for a period of two to three years and were sampled right after being converted back to conventional tillage.

Methods

Field sampling

Hidalgo sandy clay loam was selected as the benchmark soil. Nine sites under different tillage regimes were selected based on the USDA web soil survey indication of Hidalgo sandy clay loam as well as two ecological reference sites. Table 1 shows field history of the nine sites.

Table 1. Field History. Shows crop rotation for four years and history of tillage.

Site Code	Crop Rotation	Tillage History
AX1	sorghum, sesame, cotton	conventional tillage 10+ years
AX2	cotton, sorghum	conventional tillage 10+ years
AX3	cotton, corn, sorghum	conventional tillage 10+ years
AY1	sorghum, cotton	Strip tillage 2 years, followed by return to conventional
AY2	sorghum, cotton	Strip tillage 3 years, followed by return to conventional
AY3	sorghum, cotton	Strip tillage 2 years, followed by return to conventional
AZ1	cotton, sorghum	Strip tillage 4 years
AZ2	cotton, sorghum	Strip tillage 3 years
AZ3	cotton, sorghum, sunn hemp cover crop 1 year before sampling	Strip tillage 6 years
AR1	n/a	Native treeline composed of mesquite, hackberry, anacua and others. No major disturbances in over 50 years.
AR3	n/a	Native treeline composed of mesquite, Texas ebony, and others. Undisturbed in landowner's memory (60+ year). Sand deposited by strong winds.

AX shows conventional, AY shows intermittent, AZ shows strip till, and AR shows reference. The numbers following the letter indicates the field.

Figure 1 shows sampling location and Figure 2 shows sampling schematic. On each field three sites were sampled by taking two one-meter-deep cores using the Edelman probe and eight ten-centimeter-deep cores of the top were taken per location. The cores were then separated by six depths (0 - 5 cm | 5 - 10 cm |10 - 30 cm | 30 - 50 cm | 50 - 80 cm |80 - 100 cm) for a total of 198 samples. Initial in field soil characterization was planned following Schoeneberger (2012), however due to timing issues this were then conducted by NRCS one year after sampling.

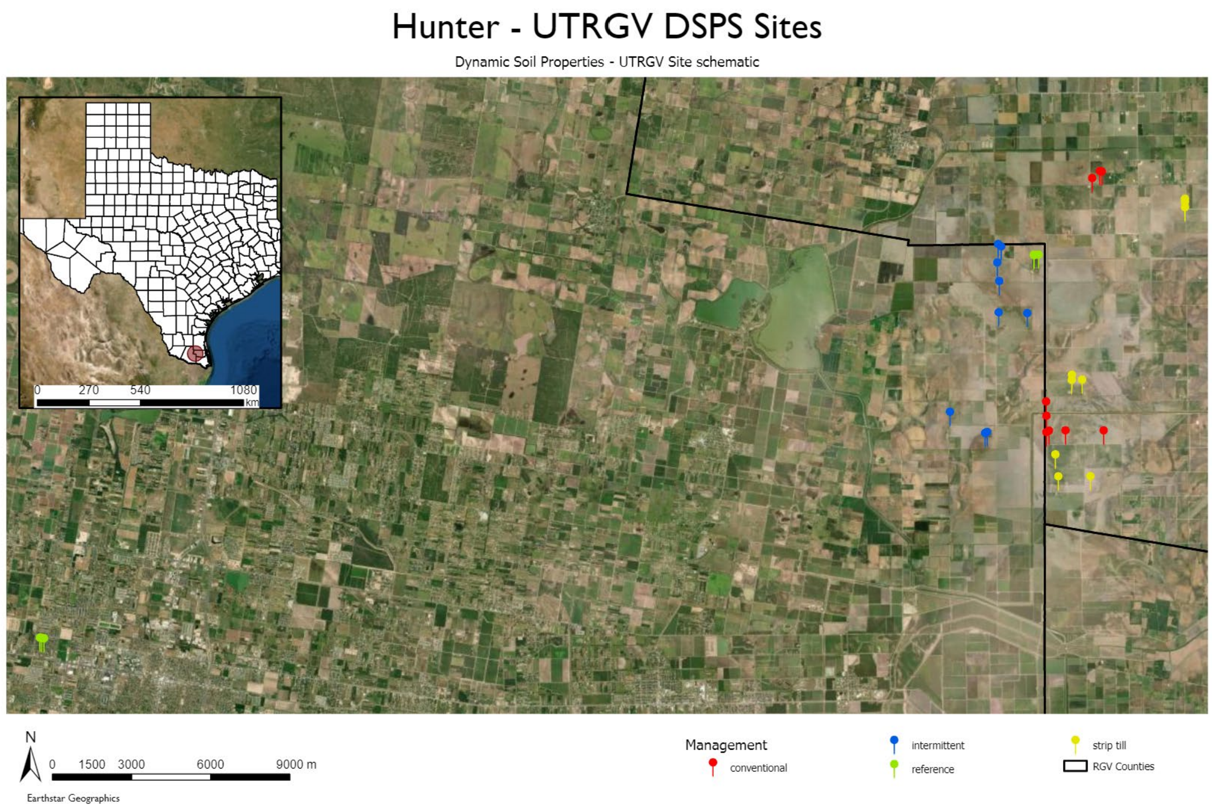

Figure 2 Sampling Locations Map
Eleven total fields were located within Hidalgo and Willacy County Texas: 2 ecological (green) references, 3 intermittent tilled (blue), 3 conventionally tilled (red), and 3 stripped tilled (yellow).

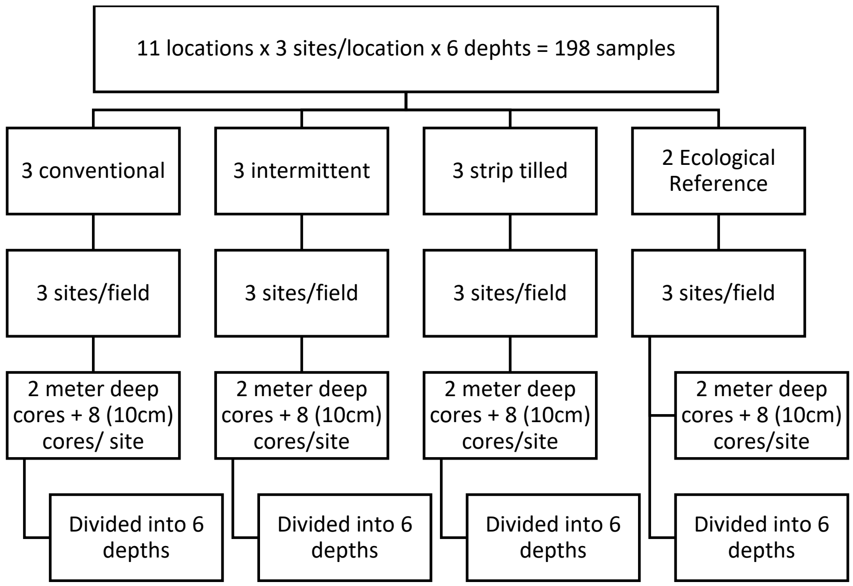

Figure 3 Sampling Schematic

Eleven locations were identified, nine under different tillage regimes and two ecological references. On each location three sites were sampled at six depths making it a total of 198 samples.

Soil Processing

All samples were processed prior to laboratory procedures by air drying in paper bags for 2 weeks and then stored in air tied Ziploc bags for further testing. For all testing, air dried samples were grounded using a mortar and pestle and sieved to < 2mm.

Soil Laboratory procedures

All samples underwent the following laboratory analyses after being processed:

Soil Inorganic Carbon (SIC) was calculated as a percent $CaCO_3$ following the Kellogg Soil Survey Laboratory Manual (KSSL) No. 42, Version 5.0 pp 370-374. The amount of carbonates in the soil was measured by reacting 0.5g – 2g of soil (depending on the effervescence) with 3 N HCL and measuring the evolved carbon dioxide after 1 hour using a monometer. The amount of carbonates is then calculated as a percent of $CaCO_3$ (Soil Survey Staff, 2014). This laboratory analysis required specialized equipment such as the voog jars to keep the produced CO_2 from leaking and yielding incorrect measurements. Additionally, as per Nelson (1982) the calculated $CaCO_3$ is only semiquantitive.

Total Soil Carbon (TC) & Total Soil Nitrogen (TN) was calculated using the dry combustion method on an elemental analyzer following KSSL Manual No.42, Version 5.0 pp 464-471. For this test we used a LECO CN928, and preformed calibration and systems check every 40 to 50 samples as suggested by the methodology. TC and TN was then converted to ppm (mg/kg) by multiplying by 10000. The results were used to calculate C:N ratio.

Permanganate Oxidizable Carbon (POXC) was estimated using principles of bleaching chemistry by using potassium permanganate to oxidize the organic matter causing a color change following KSSL Manual No.42, Version 5 pp 505 -508. Five grams of soil is combined with 20mL of 0.02 M KMnO4 causing a pink color change which is read at 550 nm using a spectrophotometer (Soil Survey Staff, 2014). The lightening of the color is proportional to the amount of POXC present in the sample (Soil Survey Staff, 2014). The results are considered an indicator of labile soil organic carbon also referred as "active carbon" .

Soil Organic Matter (SOM) by Loss on Ignition– was calculated using loss on ignition (LOI) which is the most widely used method for measuring soil organic matter in soils following the KSSL Manual No.42, Version 5.0 pp 716 with time adjustments as recommended by faculty and from Hoogsteen et al (2015). Samples were processed and oven dried in crucible overnight at

transferred i s

Data Analysis

Each dataset underwent quality control as suggested on their corresponding procedure. Once data met quality control parameters it was run through a linear mixed model using RStudio version 4.1.1 and plotted by depth and management (Figures 1-6). The statistical design considers depth and management as fixed effects since they are constant across all samples and interactive factors of high interest; Clay content is a covariate of fixed effect. On the contrary, fields are considered random effects as they represent sources of variation across our data. The linear mixed model nested field within management produced the p-values (Table 1) showing significant effects ($p<0.05$) and post-hoc analysis was conducted using the Sidak method for pairwise comparisons.

Results

Results show that management had a significant impact on POXC, TC, and SOM (Table 1); Additionally, there was a significant interaction effect between depth and management showing that the effect of management changes based on depth for TC, TN, C:N, and SOM (Table 1). Results also show that ecological reference sites on average are significantly higher than those fields under conventional, intermittent and strip tilled for TC (Fig 5), TN (Fig 6), and SOM (Fig 7) for the top 0 – 5 cm. POXC (Fig 4) on ecological reference sites was significantly higher from 0 – 5 cm, 5 – 10 cm, and 30 – 50 cm. However, when comparing conventional tillage to intermittent and strip there was no statistically significant difference among TC (Fig 5), TN

(Fig 6), SOM (Fig 7), POXC (Fig 4), and C:N (Fig 9) at all depths. Finally, most significant differences among the parameters measure could be observe on the top 0 – 10 cm except for SIC (Fig 8) due to the regions soil high content of calcium carbonates.

Table 2 P-values by Analysis of Variance (ANOVA) for permanganate oxidizable carbon (POXC), Total Carbon % (TC), Total Nitrogen % (TN), Carbon & Nitrogen Ratio (C:N), Soil Organic Matter (SOM), and Soil Inorganic Carbon (SIC). P-values below ($p<0.05$) indicate a significant difference and p-values greater than ($p > 0.05$) show no significant difference between the variables. Asterisks presented show level of significance.

	POXC	TC	TN	C:N	SOM	SIC
Depth	-	0.0262399*	1.054e-06 ***	0.007818 **	5.901e-08 ***	5.742e-06 ***
Management	0.0048563**	0.0364721*	-	-	0.04656 *	-
Percent clay	0.0005167***	-	-	-	-	-
Depth: Management	-	0.0009653***	3.976e-09 ***	0.0004502 ***	3.342e-06 ***	-
Field	6.102e-06***	0.001435**	0.000113 ***	-	9.6e-06 ***	0.0004807 ***

(-) Not significant and significant codes: < 0 '***' 0.001 '**' 0.01 '*'

POXC – Figure 4 shows at 0 – 5 cm on average POXC in refence sites is significantly higher than in conventional fields (0.5 decrease from reference to conventional); At 5 – 10 cm on average POXC in reference fields is significantly higher than conventional fields (0.5 decrease from reference to conventional); At 30 – 50 cm on average POXC in reference fields is significantly higher than on conventional fields (0.5 decrease from reference to conventional). At 0 - 5 cm and 5 - 10 cm intermittent, strip till, and conventional show no significant difference between each other.

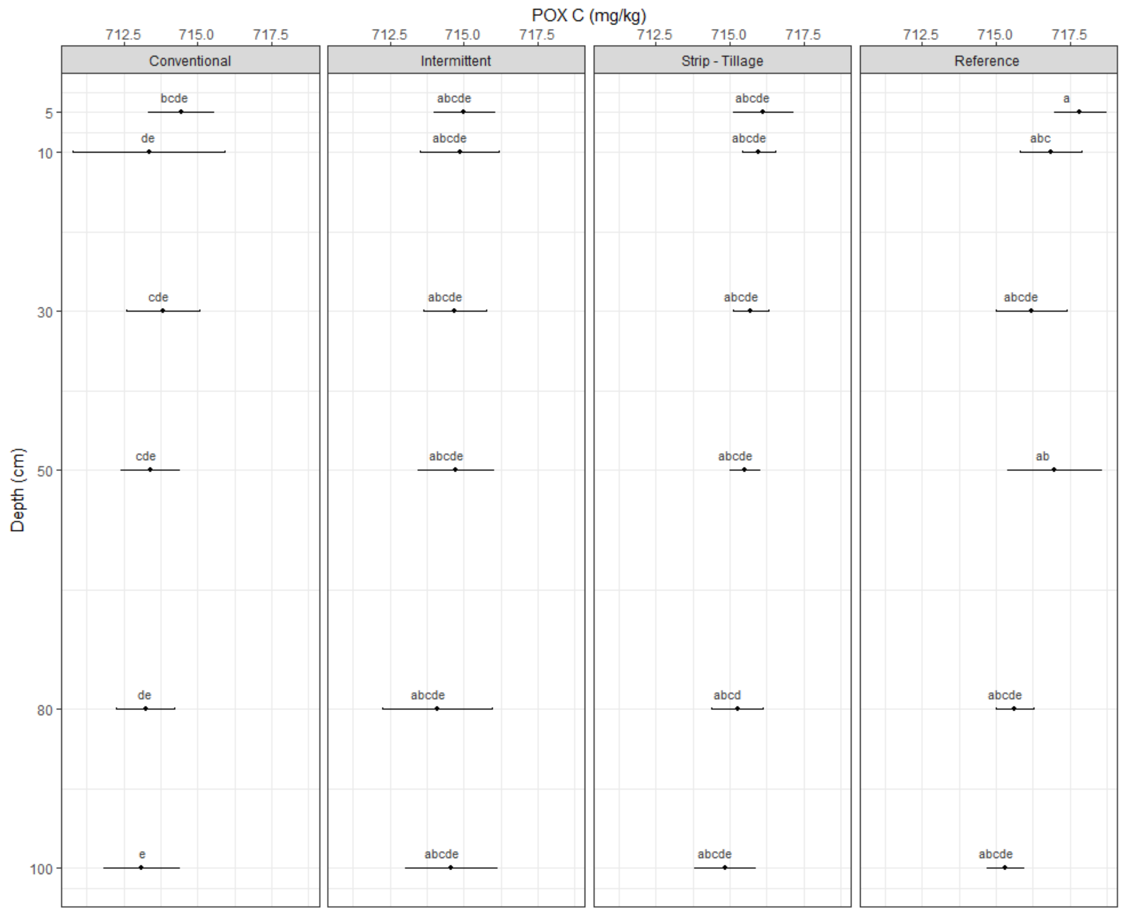

Figure 4 Permanganate Oxidizable Carbon (POXC) by Depth

The dot indicates mean, line indicates standard deviation, and sidak lower-case letters indicate significant difference: shared letters indicate no significant difference.

TC – Figure 5 shows at 0 – 5 cm on average total carbon at reference sites is significantly higher than in conventional sites (57.99 % decrease from reference to conventional); At 0 – 5 cm on average total carbon at reference site is significantly higher than conventional sites (68.25% decrease from reference to conventional); At 0 – 5 cm on average strip tilled was not significantly higher than conventional or intermittent and not significantly smaller than the reference sites. From 5 - 100 cm there is no significant difference in total carbon by practice, this in confirmed by Table 1 showing that the effect of management changes based on depth.

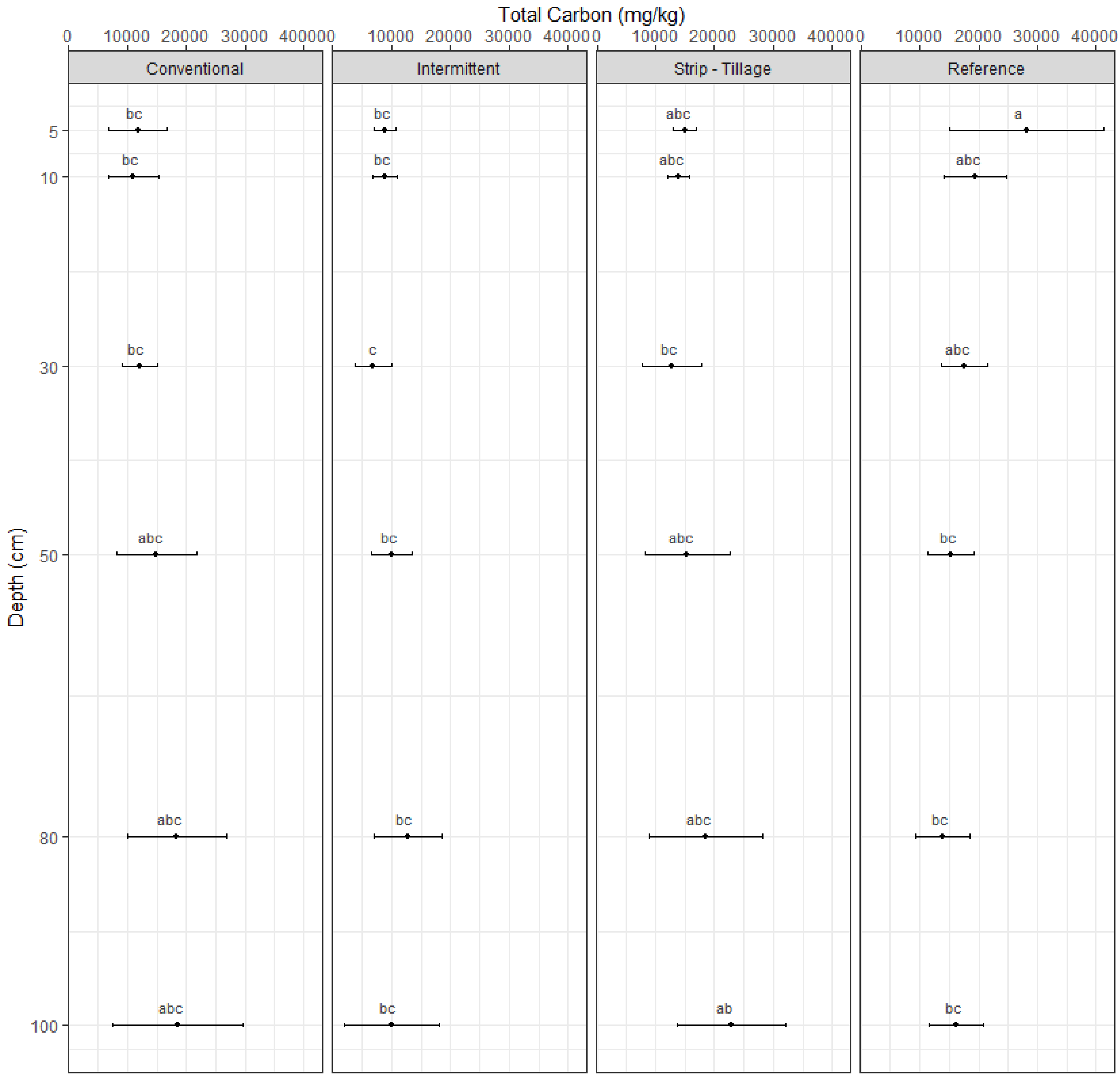

Figure 5 Total Carbon (mg/kg) by Depth.

The dot indicates mean, line indicates standard deviation, and sidak lower-case letters indicate significant difference: shared letters indicate no significant difference.

TN – Figure 6 shows at 0 – 5 cm reference sites on average are significantly larger than conventional sites (62.38% decrease from reference to conventional); At 0 – 5cm reference sites on average are significantly higher than intermittent sites (73.22% decrease from reference to conventional); At 0 – 5 cm reference sites on average are significantly higher than strip tilled sites (80.62% decrease from reference to conventional). At 0 – 5 cm strip tilled sites are not significantly higher than conventional of intermittent sites. From 5 – 100 cm there is no significant difference between management practice, this in confirmed by Table 1 showing that the effect of management changes based on depth.

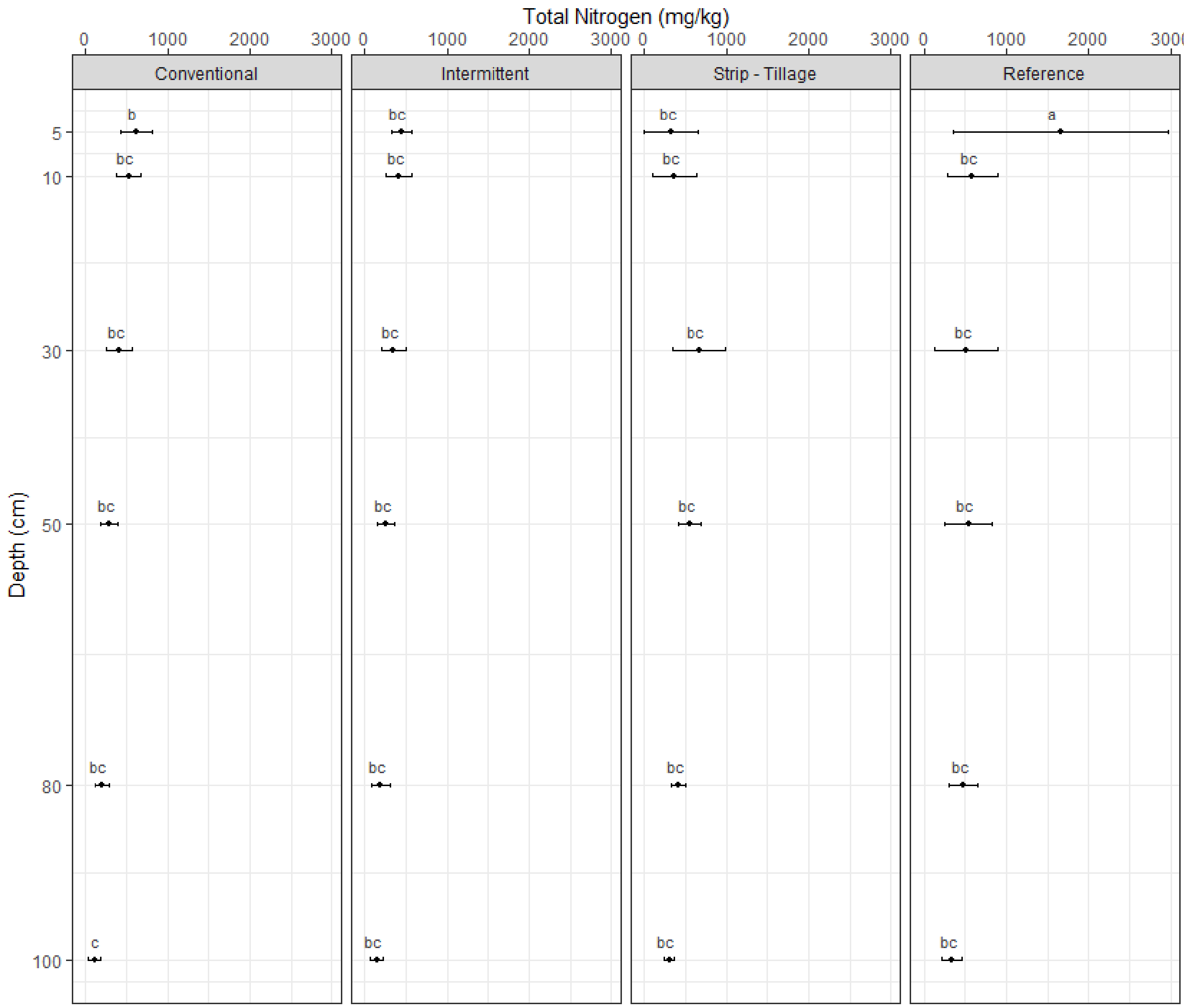

Figure 6 Total Nitrogen (mg/kg) by Depth

The dot indicates mean, line indicates standard deviation, and sidak lower-case letters indicate significant difference: shared letters indicate no significant difference.

SOM – Figure 7 at 0 – 5 cm on average the reference sites are significantly different than conventional sites (53.49% decrease from reference to conventional); At 0 – 5 cm reference sites on average are significantly higher than intermittent sites (73.25% decrease from reference sites to intermittent); At 0 – 5 cm reference sites on average are significantly higher than strip-tilled sites (66.76% decrease from reference sites to strip tilled); From 5 – 100 cm there is no significant difference between management practices, this in confirmed by Table 1 showing that the effect of management changes based on depth.

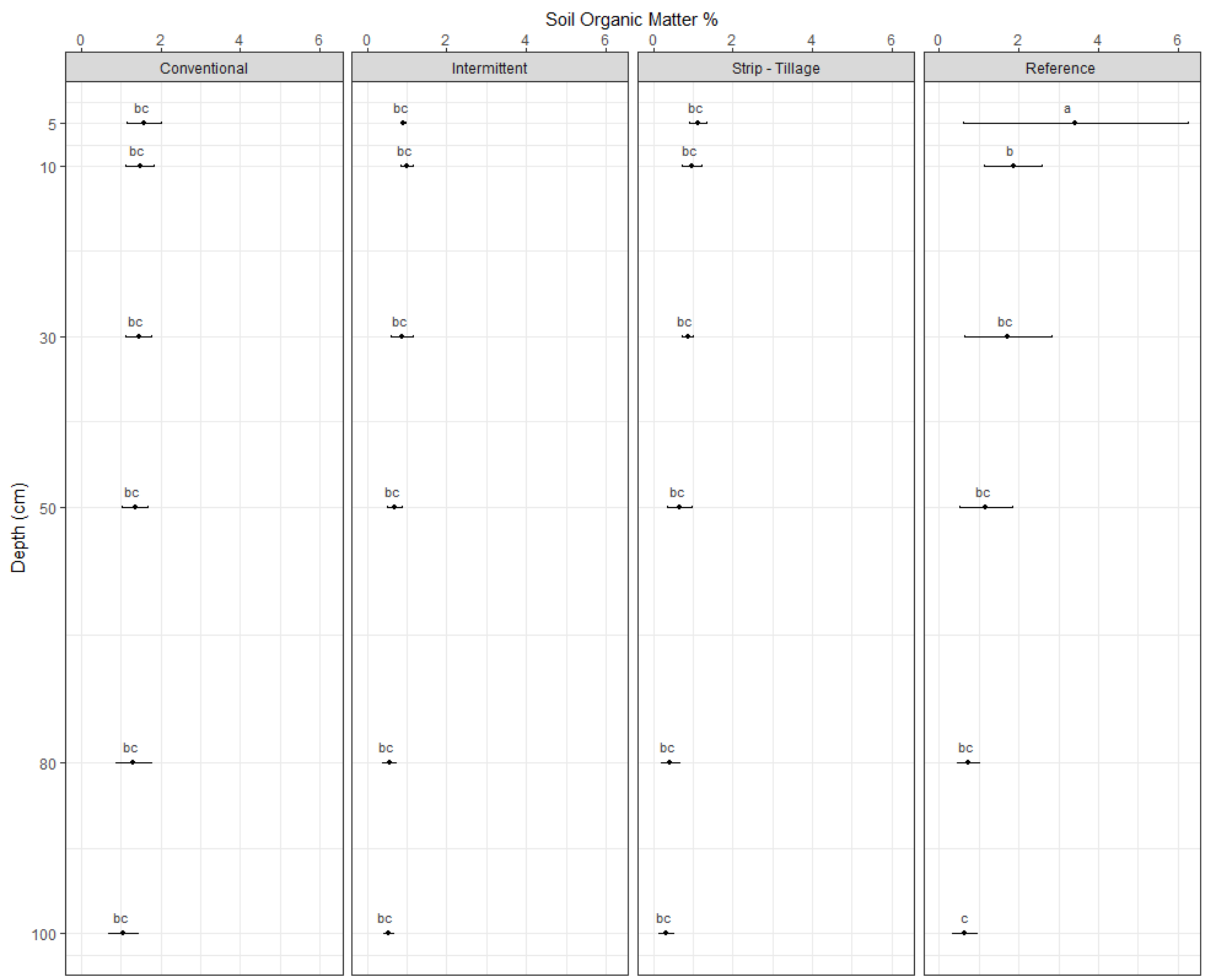

Figure 7 Soil Organic Matter % by Depth

The dot indicates mean, line indicates standard deviation, and sidak lower-case letters indicate significant difference: shared letters indicate no significant difference.

SIC – Figure 8 at all depths there is no significant differences among the conventional, intermittent, strip tilled, and reference sites, this is also confirmed by Table 1 which shows there is no significant effect by management. Table 1 and Figure 5 only show a significant effect by depth where 0 – 5 cm depth is significantly smaller than 80 – 100 cm depth on the conventional sites.

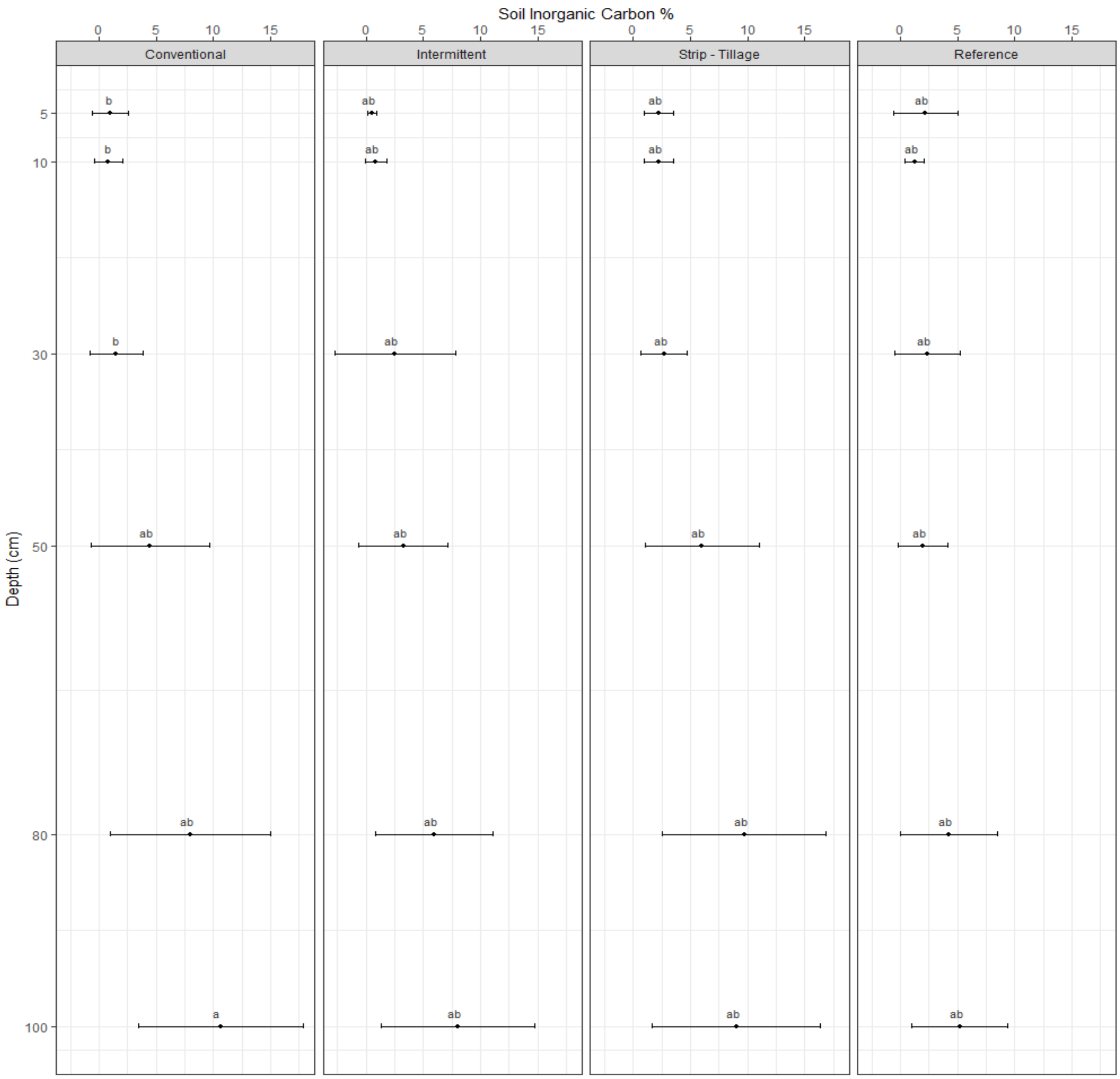

Figure 8 Soil Inorganic Carbon % by Depth

The dot indicates mean, line indicates standard deviation, and sidak lower-case letters indicate significant difference: shared letters indicate no significant difference.

C:N – Figure 9 at 0 – 5 cm, 5 – 10 cm, 10 – 30 cm, 30 – 50 cm, and 50 – 80 cm there is no significant difference between management practices. At 80 – 100 cm on average reference sites are significantly lower than conventional and intermittent sites, at this depth this significance might be because of the regions high carbonate content as also shown in Figure 8.

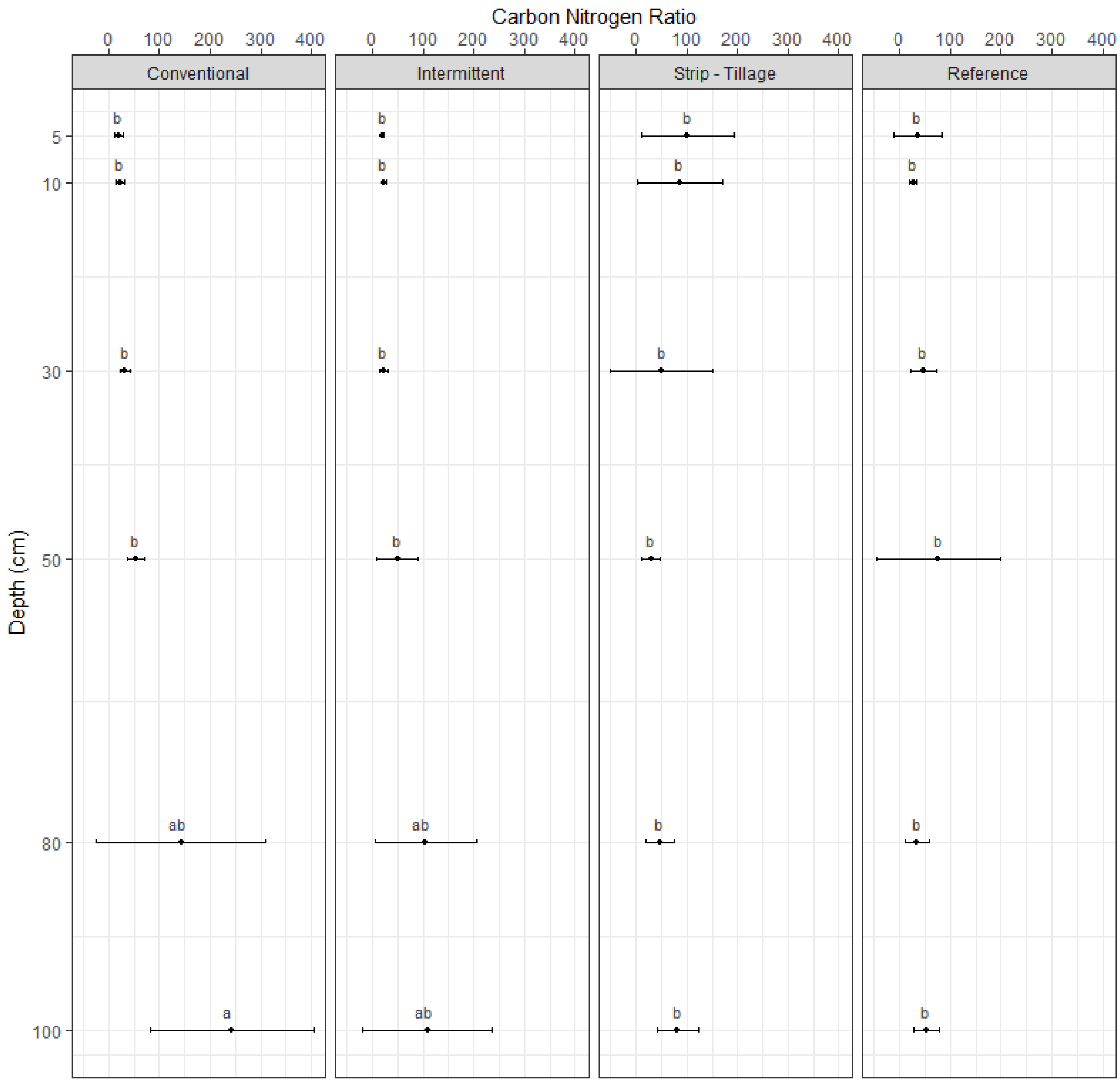

Figure 9 Carbon-to-Nitrogen (C:N) Ratio by Depth

The dot indicates mean, line indicates indicate standard deviation, and sidak lower-case letters indicate significant difference: shared letters indicate no significant difference. For this graph sample UTRGV ID 188 was dropped as it was an extreme outlier driving the standard deviation of the graph extremely high for the reference site at 5 – 10 cm.

Discussion

Tillage is done to prepare the soil for planting by temporarily alleviating compaction and boosting biological activity in addition to controlling weeds, however, that continuous physical disruption affects soil structure directly impacting soil biology and increasing deterioration of the ecological environment (Huang, 2018). Continuous soil disturbance like conventional tillage usually equates to lower soil organic matter and lower soil organic carbon and nitrogen due to the loss of structure (Jacinthe P.-A, 2005; Zibilske, 2007; Jemai et al., 2013). The soil metrics observed in this research represent a fraction of the soil dynamic properties that respond to management change; Some soil metrics could be said to be less dynamic than others and change due to short term conservation tillage implementation are hard to measure (Caudle, 2020; Vita, 2020). Additionally, the contrast observed in soil organic matter, soil total carbon and nitrogen can be further examined by increasing the number of sampling sites and the timing of samples to better understand seasonal variability, as well as fractionating these two further into types of inorganic nitrogen and organic carbon . Understanding seasonal changes in soil carbon and nitrogen could aid in understanding the dynamic of these elements on agricultural fields that are transitioning from conventional to conservation/regenerative. This is important because current research on soil carbon dynamics for transitional operations show conflicting results on the extent in which conservation tillage can increase organic matter and soil organic carbon in hotter climates (Alam, 2014; Parajuli, 2020; Potter et al., 1998; Zibilske et al., 2002). Further observing how long does the implementation of conservation practices like strip tillage take to start changing the ecological state of degraded fields needs to be observed, and to what extent does combining conservation practices speeds up the process of soil health amendment. This is important for producers in the region as they could potentially be looking at possible economic benefits from soil health benefits as Ribera et al. (2004) calculates, and better sets realistic expectations.

CHAPTER III

CONCLUSION

Our findings indicate that for the fields sampled, changes in SOM, TN, TC occur mostly on the top 0 - 5 cm (Fig 5 - 7), with no significant difference in SOM, POXC, TC, TN because of individual implementation of strip-tillage for 3 - 6 years. TC, POXC and SOM show no significant difference for intermittent fields in comparison to strip-tilled disproving the initial hypothesis that reducing disturbance for a short amount of time (- 6 years) would have a significant impact in soil carbon. Most significant differences occur between the ecological reference sites and the conventional sites for soil carbon which was expected given ecological reference sites are undisturbed. While results show that fields under strip-tilled it are not statistically higher than conventional sites, they are also not statistically lower than reference sites for TC which can be interpreted as a transitional phase. Furthermore, conservation tillage was used as the only soil conservation method for a relative short amount of time compared to other literature which study fields for 8 to 10 years with moderate improvements (Pearson, 2023). Finally, it can be concluded that strip-tilled for 3 to 6 years on an otherwise conventional operation does not significantly increase total carbon or total nitrogen. However, the lack of a statistically significant increase in total carbon and total nitrogen does not necessarily show that implementation of strip tillage in the Rio Grande Valley (RGV) is futile, as other more dynamic parameters (biologically driven) can show significant changes that indicate soil health. Future research in the region should investigate if implementing cover crops along with strip tillage has a greater effect in soil carbon and soil microbiology by measuring more dynamic indicators such as POXC, B-Glucosidase, and PLFAs and how economically viable would long term implementation of conservation tillage for local producers.

The Tillage Paradigm

Farmers till their soils for a variety of reasons and in a variety of ways. For example, tilling the soil is an organically approve way in limiting herbicide resistant weeds before planting. Additionally, farmers till the soil to incorporate manure or fertilizer, to temporally break hard compaction that occurs, and to allow for soil to absorb heat more rapidly for early planting in cool and wet regions (Classen et al., 2018; Ogieriakhi & Woodward, 2022). However, research all over the United States state the same - tillage increases soil degradation at various levels, exasperating erosion and loss of carbon (Pearson, 2023; Zibilske & Bradford, 2007; Claassen, 2018; Huang et al., 2018; Potter et al. 1998). So, if it is proven to be detrimental to soil carbon why is no-till or strip-till more widely adopted?

Tillage Compaction - Positive Feedback Loop

Tillage initially loosens the topsoil and temporally alleviates compaction, however as described in Anguelov et al. (2020) compaction usually quickly returns due to the destruction of aggregates. The long-term effect of compaction as a result of tillage initiates a positive feed back loop were the more tillage, the more compaction but also the more you need to till. As Via (2021) mentions the tillage is a temporary solution for a compaction problem. Additionally, as Strickler (2018) describes the continual effect of tillage creates a compressed layer below , otherwise known as a plow/hard pan, that impedes the infiltration of water and thus can exasperate ponding conditions. The impediment of water infiltration as a result of continual conventional tillage is important because as climate change makes weather patterns more unpredictable in the RGV it could make flooding worse which could also damage crops and farm infrastructure.

Scientific Methodology

Initially it was our goal to measure soil organic carbon following the Kellogg Soil Survey Laboratory Manual (KSSL) Manual No.42, Version 5.0 pp 464-471, however as we see in Figure 9 the Lower Rio Grande Valley Region is high in carbonates making the soil inorganic carbon reading at times higher than the total carbon reading making it unviable to subtract and thus get the soil organic carbon. While the procedure to obtain otal arbon using the CN analyzer is straight forward and easy to follow the (KSSL) No. 42, Version 5.0 pp 370-374 proved to be somewhat unreliable when working with calcareous soils. Even though the equipment met KSSL guidance often the CO_2 would leak out of the voog jars producing lower readings or would break as a result of the pressure. Additionally, while we did our best job to quality control the data obtain it still was not compatible with that of Total Carbon. Total Carbon was then reported in ppm (mg/kg) as opposed to kg/hec since the literature reports Soil Organic Carbon onverted to metric units and not Total Carbon (Lal, 2014)

Soil Organic Matter (SOM) was measure using the Loss of Ignition following faculty recommendations as well as Hoogsteen et al. (2015). While there is a lot of variability linked to the use of this procedure it proved to be relatively easy and a good way to ensure consistent readings might be by running replicates and utilizing the average. Permanganate Oxidizable Carbon (POXC) was measured using KSSL Manual No.42, Version 5 pp 505 -508 which was a quick and replicable procedure, because POXC is consider an indicator of SOM a graph of SOM vs POXC should be correlated.

If this experiment were to be replicated, we strongly encourage to measure soil organic carbon using water extractable organic carbon (WEOC) as recommended by Liptzin et al. (2022) with POXC and comparing those results with information from the World Soil Information Service or another open-source SOC in addition to using POXC as an indicator of SOM. The comparison of in-field test and models can help small scale producers make decisions on which one to use to manage and monitor their soil carbon impact, since as Liptzin et al. (2022) mentions indicators need to be “responsive to management and easy and inexpensive to collect and measure”.

Climate Smart Agriculture

Increasing attention and investment has been direct towards “climate-smart agriculture” or also called CSA which are loosely defined as implementation practices that benefits the environment in turn have positive impacts on yields and producer income in the long run (Huang et al, 2018). One of this CSA agricultural practice is conservation tillage. While it is widely understood that tilling releases CO_2 due to microbes consuming the organic matter rapidly as a result of that disruption (Stika, 2016; Via, 2021; Anguelov et al., 2020), it is also important to note that the lack of fossil fuel power equipment also contributes to a decrease in green house gas emissions. This means that not tilling directly reduces emissions due to the lack of burning of fossil fuels and not only due to the lack of soil disturbance. Additional research should focus on the impacts industrial style agriculture and loss of land to development has when compared to smaller operations in the RGV not only of soil carbon but also on functioning soil ecosystem services (Adhikari & Hartemink, 2015). This is important because smaller agricultural operations

in the RGV tend to be organic or looking to become organic (Morris & Maggiani 2016), which means they will relay on mechanize tillage to combat the regions herbicide resistant weeds while avoiding pesticides that are detrimental to pollinators and soil microbes. Finally, it is also important to develop, through future on farm research, region specific guides on transitioning from conventional tillage to conservation tillage to no-till, which consider pest, weed, pressure, and compaction issues in addition to regional benefits s i i s s s
s i s

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BIOGRAPHICAL SKETCH

Luzyannet Ballesteros Gonzalez graduated from The University of Texas Rio Grande Valley (UTRGV) , in Edinburg, Texas in 2020 with a Bachelor of Science in Environmental Science and a minor in Chemistry. A Mexican immigrant and DACA recipient she found the Lower Rio Grande Valley (RGV) a place to call home. It was in the RGV where Luzyannet first became aware of the intersectionality between environmental science, environmental justice, and agriculture. With a passion for environmental science and helping people that had been developing since being a toddler, Luzyannet decided to stay in the RGV for her graduate studies, as part of the UTRGV Agroecology lab, led by Dr. Alexis Racelis and alumnus Stephanie Kasper. She completed her Master of Science degree in Agriculture, Environmental, and Sustainable Sciences in December 2022. Luzyannet can be contacted at luz_b1013@icloud.com.