COMMENTS

General comments

This manuscript addresses the impact of cropping systems on macronutrient distribution and microbial biomass in drought affected soils. Soil samples were taken from various land types differing in terms of crops and water availability. Based on the physicochemical characterization and fumigation, the distribution of macronutrients and microbial biomass were assessed in three depth increments down to 45 cm. ANOVA were used to identify differences across cropping systems. Pearson correlation analyses were used to identify relationships between microbial and physicochemical soil parameters. Perennial crops with multiple species show the highest content in microbial biomass, nutrients and water-holding capacity compared to all other crop systems. The authors conclude that diverse cropping systems can effectively enrich soil nutrients and biomass content during drought stress.

Justification: Thank you for your comment

While this issue is relevant in terms of the increasing risk of drought to soils and sharing best practice on how to adapt agricultural practices accordingly, the manuscript does not provide novel results or convincing data. In general, the manuscript contains many too general and repetitive statements, and the wording is hard to follow. The manuscripts do not provide any specific research questions, testable hypotheses or theory driven rationale. Thus, there is no storyline which could guide the reader through the manuscript. The method section does not provide details on how the physicochemical and microbial analysis were conducted. Thus, the confidence of this data cannot be evaluated. The discussion is not data-driven and contains too may speculative and over-simplified statements. Since there are so many concerns and flaws regarding the scientific quality (see details below), I am afraid that this manuscript is not suitable for publication.

Justification: Thank you for your comment, here are few justifications about the work which was conducted, trying to justify each and every comment.

Below are the edits and comments on the manuscript

Abstract

Does not provide the novelty of the manuscript.

Justification: Thank you for your comment; I believe that the abstract does provide some novelty of the manuscript, as the manuscript underwent assessment of different land types, which included open lands, annual crops, perennial crops and less water available lands, crops close to ponds to elucidate the distribution of macronutrients and microbial biomass. Studying different land types in relation to microbial biomass and soil health provides insights into the diversity of cropping systems, secondly, focus has been made particularly on drought-affected regions where the impact on soil microbial biomass and nutrient utilization remains unexplored, by investigating the response of soil health parameters to drought stress, the study addresses a significant gap in understanding sustainable agricultural practices in such regions. Furthermore, multiple cropping systems highlighted mitigating the impact of drought on macronutrient impact and soil microbial biomass. Also identified that the PCM exhibited superior nutrient availability and microbial biomass.

Line 26 – 33 is highly repetitive.

Justification : Thank you for your response from Lines 26 – 33. There are some key points, such as the importance of multiple cropping systems, specifically perennial crops with different species, increasing microbial biomass and nutrient levels in the drought-affected regions. This paragraph also provides information relating to enhancements in soil moisture and macronutrients such nitrogen, phosphorus and potassium which may be may not be considered repetitive. Overall, the whole paragraph does not repeat the main idea, it also introduces new information focusing to a complete understanding of the study findings.

Introduction

Comment: The intro is too general and hard to follow. The intro does not show in how far this manuscript provides novelty. It does not elaborate on the state of the art properly and how far this manuscript addresses the research gap. The introduction lacks specific research questions and testable hypotheses.

Justification: The introduction focuses on the relationship between soil microbial biomass, soil health, agricultural practices, and ecosystem sustainability; it emphasizes how microbial biomass in soil plays an important role in maintaining soil organic matter and biogeochemical cycles. The introduction has shown a glimpse of exploring relationships between cropping patterns, soil microbial biomass, drought resistance, and nutrient cycling, specifically in the Andhra Pradesh region. The state-of-the-art begins with the existing knowledge on the impact of land use patterns, soil properties, and nutrient availability on drought occurrence and soil health; it specifies the role of microbial activity in enriching soil nutrients and demonstrating the influence of cropping practices on soil microbial communities. There are a few questions that were tried to address, such as how different cropping systems influenced soil microbial biomass in drought-prone regions. Dynamics of soil microbial biomass in terms of soil depth and seasonal variation in these regions. The article also tried to understand the relationship between soil microbial biomass and nutrient composition, such as carbon, nitrogen, and phosphorus in drought-affected soils. The novelty of the work represents the influence of multiple cropping systems on soil microbial biomass in drought regions, focusing on the soil depths, seasonal variation, diversity, and nutrient composition.

Comment: Line 36: You need to specify what microbial biomass is indicative for.

Justification: Thank you for the suggestion of microbial biomass indicative of the activity of microorganisms in the soil, which is helpful in the decomposing of organic matter; biomass includes the consortium of bacteria, fungi archaea, indicative of soil capacity of decomposition, nutrient cycling to assess the quality and fertility of the soil.

Comment: Line 39 – 47: This section contains many generic statements and is repetitive. What factors in detail are affecting microbial density and how? Be more specific.

Justification: Thank you for putting these in line, as the paragraph does meet on several related points, not necessarily to repeat the same information, instead, it provides a holistic overview of the factors influencing the stability of soil and microbial density, the para informs about the stability and microbial density in different ecosystems and highlighted the impact of agricultural practices on soil health, it connects the colonization of microbes with nutrients and clarifying how the implementation of organic contents which affects soil characteristics and microbial biomass. The lines are reframed as:

“The stability of soil and microbial density is influenced by the type of ecosystem and availability of nutrients (Dietterich et al., 2022; Manral et al., 2023). In most agricultural practices, the widespread use of fertilizers, hybrid seeds, and pesticides contributes to the degradation of the environment, particularly to soil health. Crop productivity heavily relies on

the availability of nutrient levels in soil, which plays an important role in supporting microbial biomass. The application of organic materials enriches the soil with nutrients, helping in the colonization of microbial communities (Bastida et al., 2017). Consequently, changes in soil characteristics may become apparent."

Comment: Line 48: What do you mean with open land use systems in that context?

Justification: Here, open land refers to a region that went through natural compaction processes typically due to gravitation forces or the trampling of animals, other factors like the settling of soil particles, and heavy machinery moving through the area, which has not been cultivated for a very long time.

Comment: Line 52 – 58: Too general. Provide more details and show how this is relevant to your topic.

Justification: Thank you for your comment; lines 52 – 58 provide several important aspects of the relationship between vegetation, formation of soil organic matter, soil processes, and productivity of the soil. The paragraph will be modified as

"The vegetation employs a great effect on soil organic matter (SOM) dynamics and basic soil – forming methods, such as aggregation and podozolization (Awasthi et al, 2022 a & b). The organization of plant species within an ecosystem models the quantity and quality of organic contributions to the soil, thus inducing SOM organization. Furthermore, the impact of vegetation expands beyond organic matter inputs. Han et al. (2021) highlighted the role of floristic composition in determining SOM dynamics and original soil-forming processes. Certain plant species may release root exudates that enhance microbial activity and SOM yield, while others may have deeper root systems that influence soil aggregation and structure. Additionally, soil texture interacts with vegetation to influence soil productivity. It has an influence on the moisture retention and availability of nutrients, which further impact the microbial decomposition and cycling processes."

Comment: Line 59 – 61: How does drought affect soil erosion?

Justification: Thank you for your comment, drought significantly has a major impact on soil erosion, which has interconnection with changes in the land use pattern such as reduced vegetative cover, reduced soil stability as increasing soil compaction making soil less stable, which decreases infiltration and increases surface runoff, which further increases wind erosion where loose dry soil particles get lifted and drifted up.

Comment: Line 61 – 65: Hard to follow. Rock-weathering is not the only input of nutrients into the soil. Especially when we talk about cropland systems with fertilizer use.

Justification: Thank you for the comment, I have just modified the statement as The supply of nutrients in the soil is influenced by various processes, including rock weathering, decomposition of organic matter, and external inputs such as fertilizers (Smith et al., 2020), while rock weathering contributes minerals to the soil over long time scales, it could be one of the sources of nutrients, along with the use of fertilizers in the agricultural systems. As fertilizers provide the available macronutrients such as nitrogen, phosphorus, and potassium to support plant growth and productivity of crops. These key ingredients are also influenced by microbial activity. Furthermore, the microbial processes contribute to the transformation of nutrients between different chemical forms, making them available for plant uptake.

Comment: Line 65 – 67: I do not understand this statement. What do you mean with interaction and physical change in this context?

Justification: Thank you for your valuable comment. The statement implies that managing cropping patterns to incorporate organic matter into the soil can enhance the interaction between soil and microbes by promoting microbial activity through both physical changes to the soil environment and nutrient supply. When we talk about, maintaining the interaction between soil and microbes, we refer to managing the conditions that support microbial activity and function of the soil.

Comment: Line 70 – 72: Too general. Be more specific.

Justification: Thank you for your comment about resorting to soil microbial communities, optimizing nutrient cycling, and improving crop productivity and agricultural practices. Much focus has to be put into reducing drought stress. As per the author, diversified cropping systems support wider microbial taxa and their functional groups, compared to monoculture systems. This will improve the diversity of microbes which can increase the strength of soil ecosystems to abiotic stresses.

Comment: Line 75 – 77: This statement is not true. There are already many studies published dealing about drought-affected cropping systems and their nutrient cycling. You need to show in how far your study differs from previous once and what the novelty is.

Justification: Thank you for your suggestion; though there were many studies have been conducted in the past, the assessment of soil microbial biomass in relation to different cropping systems in drought-prone regions has been very few. Previously studies may have explored soil microbial biomass in different cropping systems but here our study focussed on drought-hit regions of Andhra Pradesh, as the area experiences water scarcity which adds a unique dimension to the research, secondly in the past the relationship between carbon, nitrogen, and phosphorus may not be extensively explored but our study fills this gap by investigating the influence of multiple cropping systems on soil microbial biomass and nutrient content. Moreover, our study also has also focussed on how different cropping patterns impact soil health in drought-hit regions, which may not have been explored thoroughly in past studies.

Material and Methods

The method section is not specific enough. Based on the provided information, it is not possible to evaluate the data quality.

Comment: General question: How was seasonality treated in the analysis? How did you differentiate between seasonality effects and drought effects?

Justification: The method adopted by collecting samples in three distinct seasons such as summer, monsoon, and winter, allows for examining the potential seasonal variation in soil characteristics and soil microbial biomass; by collecting the samples across the seasons, the study goal is to apprehension any sequential changes in soil properties and microbial communities that may occur in response to seasonal fluctuations in environmental conditions such as temperature, precipitation, and plant growth dynamics.

Comment: Line 90: More information needed. Is the study region drought-affected the whole year or during specific seasons?

Justification: The study area is located in the southern part of Andhra Pradesh, Anantapur district, predominantly semi-arid climate with distinct wet and dry seasons. The study area

often faces prolonged dry spells and water scarcity, leading to drought conditions; the dry season is mostly found from October to June, showing high water scarcity and low rainfall, and high temperatures. As it is seasonally based, not the entire year was affected by the drought.

Comment: Line 93: More information is needed about “less water available lands” and “crops grown near the ponds”. This category is based on what parameters? Do they differ in soil moisture, soil temperature, electrical conductivity, etc.?

Justification: Less water available lands have limited access to water, making them more prone to drought stress; crops near the ponds have close proximity to ponds and reservoirs, including parameters such as soil moisture, soil temperatures, and electrical conductivity. In case of less water availability, lower soil moisture, high soil temperature, and higher electrical conductivity will be recorded due to increased soil salinity due to water-stressed conditions. In the case of crops near the ponds, increased soil moisture, lower soil temperature, and lower electrical conductivity due to reduced soil salinity.

Comment: Line 108: What the soil temperature measured in the field?

Justification: Resistance thermometers are used to measure accurate and stable temperatures buried at different soil depths for monitoring.

Section 2.3: You need to provide more details about your methods. The reader cannot reproduce your analysis based on the provided description.

Justification: Thank you for your comment. The methods that are provided have followed the standard protocols, which have been given references for each method. Here is the description of the protocols

The texture of the soil was assessed by passing soil through a sequence of sieves with varying aperture sizes: Sand (0.02-2.0 mm), silt (0.002-0.02mm), and clay (<0.002 mm). The soil particles composition was then determined by weight, following the method outlined by Misra (1968). Bulk density has been determined using a specialized metal core sampling cylinder with a known volume. The soil moisture content has been calculated gravimetrically by subjecting soils to drying until reaching a constant weight, then expressing the water content as a percentage of the dry weight. The pH levels were measured in a 1:5 mixture of soil and distilled water using a glass electrode. The soil carbon content was measured using the rapid titration method devised by Walkley and Black (1934). Total soil nitrogen (Peach & Tracy 1956) was determined using the micro-Kjeldahl digestion technique, while total phosphorus was measured using a spectrophotometer, following the procedure described by Misra (Olsen et al 1954).

The microbial biomass content has been determined using the chloroform fumigation and extraction method following the protocol modified by Brookes et al., 1985. Ten grams of three portions of moist soil samples were weighed, and two portions were placed in a crucible alongside a shallow dish containing 30 ml alcohol-free chloroform. The other portion was left unfumigated and also placed in a crucible within a separate desiccator without chloroform. Both of them were covered and kept in the dark at room temperature for days Vance et al., 1987. After the fumigant was removed, the fumigated soils were extracted with 0.5 M potassium sulfate; the same was processed with non-fumigated soils. For further analysis soil extract (8 ml), 0.2 M potassium chromate (2ml), concentrated sulphuric acid (10ml), and 85% phosphoric acid (5 ml), were thoroughly mixed and the mixture was then digested at 150 C for 30 minutes and treated 0.1 N ferrous (II) ammonium sulphate, employing 2-3 drops of ferroin indicator.

Comment: Line 118: What exactly where you trying to find out by using Pearson correlations? Because table 6 contains autocorrelations.

Justification: The use of Pearson correlations has been done to explore the relationship between different microbial biomass such as C (C_{mic}), N (N_{mic}), P (P_{mic}). High positive correlations between these indices would indicate the coordinated response of microbial communities to environmental conditions. Secondly, relative proportions between these ratios provide insights into microbial community composition and pattern of nutrient utilization.

Results

Comment: The data is poorly presented. The result section already contains interpretations and generic statements.

Justification: The results that are provided are well organized and formulated in different tables and most of them are based on statistical analysis of the data, it also highlighted how interpretations contribute to the understanding of the results.

Comment: General question: Where are the ANOVA results presented?

Justification: ANOVA results are presented in tables-2,3 and 4

Comment: Line 122: Similar texture does not imply the same parental rock. And how can you be sure, that in your (sub)tropical soils the sand fraction is not influenced by microaggregates and pedogenic oxides?

Justification: Soil texture provides valuable insights into soil genesis and processes, which includes the composition of the parent material, weathering processes, and soil formation mechanisms; while similar textures may indicate some degree of geological similarity, in some cases might not conform with the same parental rock. In the case of microaggregates and pedogenic oxides, it may alter the distribution and composition of soil particles, including a fraction of sand, aggregation, and mineral weathering.

Comment: Line 123: Too general. And why is this relevant for your topic?

Justification: The present study area is composed of ancient volcanic rocks, which, over time, contribute to the formation of soil, so similar soil texture might be found across the agricultural systems deriving common geological origin.

Comment: Line 132 – 133: This is trivial.

Justification: Thank you for your comment; the above lines are not trivial, as they emphasize the variation across different agricultural systems, which has significant implications for crop production. The statement highlights the diversity of soil pH conditions within the study areas, variation in the pH may influence crop productivity.

Comment: Line 134: Increase in pH can have several reasons and not just fertilizer input.

Justification: Thank you for your comment, I do agree that the increase in pH can be for several reasons, but in the case of the study area, enhanced use of synthetic fertilizers and

pesticides to improve crop production. Due to the presence of calcium carbonate deposits naturally, most soils in this region are alkaline.

Comment: Line 137: Trivial

Justification: Thank you for your comment, but the line 137 is not trivial, as variation in electrical conductivity has an influence on the distribution of ions in the soil. The distribution of ions is crucial for optimizing soil fertility management practices to support plant growth and crop yield.

Comment: Line 145: What do you mean with 90 %. Where is this number coming from?

Justification: Thank you for your comment; the line 145 represents the total nitrogen in the soil compared to other components.

Comment: Line 152 – 167: I cannot follow this section. This is already interpretation and is not linked to any hypothesis. The different season were not described in the method section before.

Justification: Thank you for your comment on the lines 157 -162. In these lines, the interpretations aimed to provide an understanding of the observed variation in microbial biomass and nutrient concentrations across different cropping systems and seasons. As interpretations are valuable for insights into the implications of the findings, which are supported by clear hypotheses. The samples were collected during three seasons to recite the importance of considering seasonal effects on soil properties and microbial dynamics.

Comment: Line 170: This is simply an autocorrelation.

Justification: Thank you for the comment, the use of Pearson correlations has been done to explore the relationship between different microbial biomass such as C (C_{mic}), N (N_{mic}), P (P_{mic}). High positive correlations between these indices would indicate the coordinated response of microbial communities to environmental conditions.

Discussion

Comment: Since no research question nor hypothesis were formulated before, the discussion part is not linked to any central theme. It contains to many generic and oversimplified statements and speculative parts. Further, the discussion is not data-driven.

Justification: Thank you for your comment; we have tried to address the research question of how different land types and cropping systems, particularly perennial crops with multiple species, influence soil microbial biomass and macronutrient distribution in affected regions. The study also tried to address how to various land types such as open lands, annual crops with single species, perennials with multiple species, less water available lands, and soil near ponds impact soil microbial biomass and macronutrient distribution. The study also tried to address the microbial biomass carbon, nitrogen, and phosphorus levels across different seasons and soil depths in each land type. We tried to understand how multiple cropping has an impact on soil moisture, nitrogen, and phosphorus levels in drought-stressed environments. Finally, we tried to address how these findings contribute to understanding sustainable agricultural practices and soil health resilience in drought-prone regions.

Comment: Line 178 – 188: Too general. No link to data.

Justification: Thank you for your comment; lines 178 to 188 give the importance of soil ecology, nutrient richness, and the impact of drought on soil properties, which has been demonstrated in the results segment, the findings of soil parameters, cropping systems, and their impact on soil microbial biomass has been clearly mentioned.

Comment: Line 189 – 191: Trivial. Texture is not the only factor controlling soil productivity.

Justification: Thank you for your comment; soil texture is indeed a crucial factor influencing soil productivity; it is one of the many factors that contribute to overall soil fertility and crop production. Other factors also contribute to soil health, such as organic matter content, nutrient availability, pH levels, water retention capacity, as well as biological activity. Consider a wide range of physical, chemical, and biological properties for a holistic approach to soil health assessment. While soil texture provides valuable insights into soil characteristics, it should be interpreted in conjunction with other parameters to obtain a comprehensive understanding of soil fertility and its implications for crop production. Soil productivity can vary significantly across different soil types, even within the same texture class.

Comment: Line 192 –197: I do not understand the sentence.

Justification: Thank you for your comment; here is the explanation: In LWA lands, the proportion of sand is higher than silt and clay compared to other lands with different crops. This might be due to the erosion of finer soil particles such as silt and clay due to lower vegetation cover and activities of agriculture in LWA areas. As limited crops are present in such regions, there will be reduced soil cover and root structure to protect against erosion, leading to the displacement of finer particles by sand. So, soils in LWA have a higher content of sand than silt and clay.

Comment: Line 197 – 198: This is trivial.

Justification: Thank you for your comment; the line 197-198 highlight an essential aspect of soil science and agricultural productivity. It represents a fundamental principle in soil science: soil water holding capacity influences water retention, which has a great impact on agricultural productivity.

Comment: Line 199 – 200: You are jumping to conclusions. There are many more factors other than crop types affecting water holding capacity (texture, bulk density for example).

Justification: Thank you for your comment; there could be many factors influencing water holding capacity, such as soil texture, bulk density, and organic matter content, but multiple cropping may contribute to increased water retention. As the study area, falls into a drought-hit region, multiple cropping may enhance soil organic matter content and improve soil structure, leading to increased water retention, its effectiveness may vary.

Comment: Line 200: The existence of irrigation facilities on your test sites were not mentioned in the methods before. This comes as a surprise now. How do you isolate this effect from seasonality effects for example?

Justification: Thank you for your comment, irrigation practices can both influence soil properties and microbial biomass, the data also represented that different cropping patterns influence of soil properties and microbial biomass

Comment: Line 204: Again, there are more factors influencing bulk density. This is too simplified.

Justification: Thank you for your comment; line 204 explains that during cultivation, soil gets compacted, resulting in higher bulk density as one of the several factors that can affect soil density. Secondly, other factors such as soil moisture levels, topography, and land management practices are also influenced. Moreover, soil, climate, and cropping patterns also result in soil nature.

Comment: Line 211 –215: This is too general. Why is this relevant for your topic?

Justification: Thank you for your comment, lines 211 to 215 highlight the relationship between soil pH, cultivation practices, and nutrient management in drought-hit regions, where maintaining soil health and productivity is essential.

Comment: Rest of discussion contains many generic and oversimplified statements and is hard to follow due to wording. The impact of drought stress was not properly discussed besides being a main topic of the manuscript.

Justification: Thank you for the comment; the discussion has been focussed on the soil physicochemical parameters of different cropping patterns in drought-hit regions of Andhra Pradesh, where these kinds of study have been low; we tried to find out if the soil microbial biomass has any relevance to the cropping patterns, which was found in case PCM cropping systems. The study also visualized the seasonal variation and its influence on soil

Conclusion

Comment: The conclusion does not show what new knowledge we have learned from this study.

Justification: Thank you for your comment; the conclusions have been focussed on the importance of employing multiple cropping practices to improve the physicochemical and biological properties of drought-hit soils; it highlighted that diverse litter provides a favorable environment for microbial diversity, indicating that the selection of proper root systems and perennial crops can positively influence soil microbial communities. It emphasizes how perennial crops may influence soil pH, water-holding capacity, soil temperature, etc.

Comment: Line 298 – 299: Oversimplified

Justification: Thank you for your comment; indeed, the statement is somewhat simplified, but it effectively captures a common phenomenon in agriculture: continuous cultivation can indeed deplete soil nutrients over time, leading to soil degradation and reduced fertility.

Comment: Line 306 – 312: Plant diversity was not discussed before. This is a new aspect brought up in the conclusion.

Justification: Thank you for your comment; the meaning of lines 306-312 was that if the drought-hit regions were improvised with multiple cropping systems, then there could be more chances for diverse plant species to be grown.