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Influence of Tillage and Weed Management Strategies on Soil Microbial Biomass and Dehydrogenase Activity in Maize (*Zea mays* L.) Cultivation

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ABSTRACT

The purpose of this study is to investigate soil biological activities in vertisols, specifically exploring the influence of conservation tillage and different weed management strategies on maize production. Utilizing a strip-plot design, two tillage methods (conventional and reduced) were implemented as vertical strips, while seven weed management strategies formed horizontal strips. Although CT and RT don't differ significantly in terms of soil microbial mass and dehydrogenase activity, herbicides, a dominant weed management method, have been shown to harm soil microbes. The weed management strategies implemented had noteworthy effects on both soil microbial biomass and dehydrogenase activity, signifying substantial impacts on these aspects of the soil. Notably, maize intercropped with cowpea exhibited higher microbial mass and dehydrogenase activity compared to treatments involving herbicides, hand weeding, and a weedy check. These findings provide quantitative insights into the soil health implications of different agricultural practices in vertisols.

Keywords: *Conservation tillage, Dehydrogenase, Maize, Reduced tillage, Soil Microbial Biomass, Weed management.*

1. INTRODUCTION

Maize (*Zea mays* L.) holds global significance as a vital cereal crop essential for ensuring food security and sustaining agricultural economies. The sustainable production of maize relies not only on genetic advancements but also on the management of soil health. The microbial communities in the soil are essential for nutrient cycling, and the breakdown of organic matter, and make a substantial contribution to overall soil fertility. A sustainable cultivation strategy depends on evaluating the effects of agricultural practices on soil microbial activity. In agricultural systems, tillage and weed management are pivotal for shaping soil's physical, chemical, and biological characteristics. Weed control methods and soil disruption can significantly impact microbial communities by affecting the soil environment. Among the key indicators of microbial activity, dehydrogenase activity serves as a reliable marker for soil metabolic processes, reflecting the overall microbial function. The relationship between tillage, weed management strategies, and soil microbial activity in maize cultivation is complex and multifaceted. Conventional tillage, characterized by intensive soil disturbance, may impact microbial biomass and activity, while conservation tillage practices, emphasizing reduced soil disturbance, could offer more favorable conditions for microbial growth. Similarly, weed management strategies employing chemical or organic methods may have distinct effects on soil microbial communities. Our study examines how diverse tillage and weed management practices affect soil microbial activities and dehydrogenase levels during maize cultivation. By investigating these interactions, we aim to deepen our comprehension of how agricultural practices shape the soil microbial ecosystem, potentially influencing nutrient cycling, soil health, and, ultimately, maize productivity. The study spans consecutive *kharif* seasons, and the site's characteristics, encompassing soil texture, bulk density, salinity, and pH, provide a contextual framework for the investigation. Through this research, our goal is to contribute meaningful insights to the advancement of sustainable and environmentally responsible agricultural practices in maize production.

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MATERIALS AND METHODS

During the consecutive *kharif* seasons of 2018 and 2019, an in-depth field investigation took place at the Agricultural Research Station (ARS) in Tandur. The research station, positioned at 486 meters above MSL (17° 25' N latitude and 77° 58' E longitude), experienced distinctive climatic conditions during the 2018 *kharif* season, marked by a total precipitation of 347.70 mm over 31 days. Subsequently, in the following year, 2019, the precipitation increased to 675.20 mm, spread across 49 rainy days. Notably, all agricultural practices implemented during this study were solely dependent on rainfed conditions.

Physico-chemical and biological properties of the soil are presented in Table 1. The experimental design utilized a strip plot layout, consisting of three replicates. Vertical plots, each covering an area of 378 m^2, were designated for two distinct tillage methods: conventional tillage (T_1) and reduced tillage (T_2). Horizontal plots (54 m^2) were dedicated to seven weed management strategies: Weedy check (W_1), Hand weeding at 20 and 40 DAS (W_2), Maize Intercropped with cowpea (W_3), Atrazine 50% WP @ 0.5 kg *a.i.* ha^{-1} + Tembotrione 42% SC @ 120 g *a.i.* ha^{-1} (Early Post-emergence) followed by hand weeding at 40 DAS (W_4), Atrazine 50% WP @ 1.0 kg *a.i.* ha^{-1} (Pre-emergence) followed by Tembotrione 42% SC @ 120 g *a.i.* ha^{-1} (Post-emergence) (W_5), Atrazine 50% WP @ 1.0 kg *a.i.* ha^{-1} (Pre-emergence) followed by paraquat 24% SL @ 1.0 kg *a.i.* ha^{-1} (Post-emergence) (W_6), and *Sorghum bicolor* + *Parthenium hysterophorus* leach @ 15 L ha^{-1} each (Pre-emergence) *fb* by Sorghum *bicolor* + Parthenium *hysterophorus* leach @ 15 L ha^{-1} each (Post-emergence) (W_7). Maintaining a 1-meter buffer strip between the plots ensured experimental integrity. Tillage practices adopted in conventional and reduced tillage are presented in Table 2.

The maize hybrid (DHM-117) was manually planted with a planting geometry of 60 cm × 20 cm, adhering to standard cultivation practices, which excluded tillage and specific weed management methods. Herbicides and leeches were applied at distinct: pre-emergence (one day after sowing), early post-emergence (15 DAS), and post-emergence (25 DAS). The application of sprays was conducted using a handheld pneumatic backpack sprayer equipped with a wide-angle flat fan nozzle, while the application of paraquat utilized a hood. Cowpea variety, TPTC-29 was intercropped with maize, occupying two rows between the maize rows. To utilize the allelopathic properties of Sorghum and Parthenium, a method was employed involving the soaking of their oven-dried powders in water at a ratio of 1:10 (weight to volume) for 48 hours. Following the protocol detailed by Cheema and Khaliq (2000), the extracts were filtered through muslin cloth. The allelopathic extracts are likely to house bioactive compounds that can exert an implication on the growth and development of surrounding plants. A consistent fertilizer regimen was implemented, with a uniform dosage of 180, 60, and 50 kg of N, P_2O_5, and K_2O per hectare across all treatments. Entire amounts of DAP and MOP were applied as basal which provides phosphorus and potassium nutrients, respectively for plant growth. Nitrogen, supplied as urea through proportional calculation with DAP, was distributed in three phases based on the schedule: $1/3^{rd}$ as a basal application, another $1/3^{rd}$ at 30 DAS, and the final $1/3^{rd}$ at 60 DAS. This comprehensive nutrient and allelopathic management strategy aims to enhance the overall crop performance and control weed growth through the targeted application of Sorghum and Parthenium extracts.

The determination of soil bulk density was conducted following the procedure outlined by Dhakshinamurthy and Gupta (1968). The assessment of soil pH involved creating a 1:2 soil-to-water suspension, and a pH meter (Elico LI 127) with a calomel glass electrode was used for measurement. Additionally, the electrical conductivity of a 1:2 soil-to-water supernatant, settled overnight, was measured using a Solubridge (Systronic Conductivity Meter 304). The assessment of oxidizable soil organic carbon was conducted using the rapid titration method outlined by Walkley and Black in 1934. This method involves the use of a diphenyl amine indicator to facilitate the titration process.

The analysis of available nitrogen in the soil was carried out using the Alkaline $KMnO_4$ method, following the procedures outlined by Subbiah and Asija in 1956. The evaluation of soil phosphorus availability involved employing a 0.5 M $NaHCO_3$ extraction at pH 8.5, following the procedure outlined by Olsen *et al*. in 1954. The measurement of phosphorus content in the extract was carried out using a colorimetric method with a spectrophotometer set at the wavelength of 760 nm, utilizing the ascorbic acid method. The determination of soil potassium content was carried out by extracting it with a neutral 1N NH_4OAc solution and subsequently analyzing it using a flame photometer, by Jackson's 1973 method. The quantification of microbial mass in soil is typically conveyed as colony-forming units per gram of soil (CFU g^{-1} of soil). Bacterial viable counts are determined using Nutrient Agar (NA) media, fungal viable counts using Potato Dextrose Agar (PDA) media, and actinomycetes viable counts using Actinomycetes Isolate Agar (AIA) media, respectively. In the procedure, each soil sample was diluted at a ratio of 1:100 (10^{-2}) by combining 1 gram with 9 ml of sterile distilled water. The mixture was agitated for 10-15 minutes to attain a uniform suspension. Subsequently, 1 ml of the supernatant was transferred to 9 ml of a blank, resulting in a 10^{-3} dilution. This process was repeated to achieve the desired dilutions. The specific medium (Nutrient Agar, Potato Dextrose Agar, or Actinomycetes Isolate Agar) was melted at 42°C, and approximately 20 ml of the medium was poured into each petri dish. One milliliter of the soil suspension was spread onto the solidified medium. After solidification, the plates were placed in an incubator. All these steps were meticulously performed in a laminar airflow chamber to prevent contamination. The formula for computing colony-forming units per milliliter (CFU/ml) in soil using the viable count method is typically:

$$\text{CFU/ml} = \frac{\text{Number of colonies}}{\text{Quantity of sample}} \times \text{Dilution factor}$$

Where:

Number of colonies: Count of colonies on the agar plates after incubation.

Quantity of Sample: Amount of the original soil sample used (usually in milliliters).

Dilution factor: The reciprocal of the dilution applied to the sample before plating (*e.g.,* for a 1:100 dilution, the dilution factor is 100).

Dehydrogenase, located inside the cytoplasm of every living microbial cell, functions as an indicator of overall microbial activity associated with oxide-reduction processes. One-gram soil sample was carefully weighed and placed into a 50-ml volumetric flask. In this mixture, 50 mg of $CaCO_3$ was added, followed by the introduction of 2.5 ml of distilled water and 1 ml of 3% TTC (2,3,5-triphenyltetrazolium chloride). The contents were swirled for a few minutes and then incubated at 37°C for 24 hours. Following incubation, the red precipitate of triphenylformazan (TPF) was dissolved in 10 ml of methanol. The mixture was then shaken for 30 minutes using a mechanical shaker. Subsequently, the contents were filtered into a 25 ml volumetric flask and made up to a volume of 25 ml with methanol. The red color intensity was measured at 485 nm with a spectrophotometer, adhering to the protocol elucidated by Casida *et al*. (1964). The gathered data underwent averaging, tabulation, and statistical analysis utilizing the strip-plot experimental design, following the methodology recommended by researchers Gomez and Gomez (1984). This approach helps to systematically assess and interpret the results of the experiment.

2. RESULTS AND DISCUSSION

Bulk Density (g cm^{-3})

The analysis of data showed that there were no notable distinctions in the impact of individual or combined tillage and weed management strategies on soil bulk density after the maize harvest. However, there was a marginal difference observed in surface soil (0-15 cm) between CT and RT. Specifically, conventional tillage showed a slightly lower BD (1.43 and 1.44 g cm^{-3}) compared to reduced tillage (1.45 and 1.48 g cm^{-3}) during 2018 and 2019. The diminished bulk density in CT is ascribed to the influence of extensive tillage methods, which induce an expansion of soil volume, consequently leading to a reduction in bulk density. In contrast, the abundant clay composition of the soil in the present study, combined with low soil porosity in RT, led to the formation of strong columnar aggregates. This arrangement led to an upsurge in soil bulk density within the reduced tillage plots. These observations are consistent with results obtained in research by Gholami *et al.* (2014) and Khan *et al.* (2017), underscoring the influence of tillage practices on soil bulk density. This underscores the crucial consideration of soil structure and composition in agricultural management decisions.

Soil Reaction (pH)

No remarkable differences were noted in the individual and combined impact of tillage and weed management strategies on soil pH after the maize harvest. The decline in soil pH associated with reduced tillage (RT) was ascribed to an elevation in organic carbon content. This increase in organic carbon content resulted from lower oxidation of organic carbon due to fewer disturbances in the soil associated with reduced tillage practices. Notably, low soil pH values (7.83 and 7.79) were recorded in the intercropping with cowpeas among different weed management strategies during 2018 and 2019, respectively. This phenomenon can be understood by considering that legumes, such as cowpeas, which have been inoculated with rhizobia bacteria, obtain their nitrogen (N) directly from the air as diatomic N, as opposed to extracting it from the soil in the form of nitrate. This process has a net effect of reducing the pH of the soil. The outcomes of this investigation are in harmony with the data presented by Baskaran (2013) and Patel *et al.* (2020), indicating a convergence of evidence across studies concerning the impact of tillage, weed management, and intercropping practices on soil pH after maize harvest. Understanding these dynamics is crucial for informed decision-making in agricultural practices and soil management.

Electrical Conductivity (dSm^{-1})

An observation revealed that there was no significant difference in the effect of individual and combined tillage and weed management strategies on the soil's electrical conductivity (EC). Despite the absence of significant differences, conventional tillage exhibited a decrease in EC. The reduction in electrical conductivity (EC) observed in conventional tillage was linked to the loosening of the topsoil layers, leading to improved air circulation. This process facilitated enhanced leaching in the surface soil. These outcomes are consistent with the discoveries of Kumar *et al.* (2018) and Patel *et al.* (2020), demonstrating a consensus among various studies regarding the influence of tillage practices on soil electrical conductivity.

Gaining insight into the impact of tillage on electrical conductivity (EC) is crucial for understanding the post-crop harvest dynamics of soil properties. This knowledge provides valuable perspectives for the implementation of sustainable soil management practices in agriculture.

Organic Carbon (%)

The data showed no significant differences in the individual and combined effects of tillage and weed management strategies on soil organic carbon after maize harvest. The reduced organic carbon content in conventionally tilled soil (CT) is ascribed to heightened oxidation of organic carbon resulting from intensive tillage. This leads to a dilution of organic carbon concentration in the topsoil. Overall, these findings emphasize the importance of considering tillage practices, such as conventional tillage, in soil management decisions, as they can significantly impact soil organic carbon levels and, consequently, soil health. Reduced tillage practices are linked to lower decomposition rates of soil organic matter, resulting in an accumulation of organic carbon content over time. This suggests that minimizing tillage disturbance in the soil has a positive effect on preserving and accumulating organic carbon. The slower decomposition under reduced tillage allows organic matter to persist within the soil, adding to improved soil organic carbon levels. This information underscores the potential benefits of adopting reduced tillage practices in agricultural systems for enhancing soil carbon sequestration and overall soil health (Gwenzi *et al.* 2009). Higher organic carbon content (0.37 and 0.39%) was recorded in maize intercropped with cowpea, among different weed management strategies during 2018 and 2019, respectively due to the addition of organic matter through leaf fall and subsequent decomposition by microorganisms. Thierfelder *et al.* (2012) noticed a substantial 31% increase in soil carbon content when cowpea and sunnhemp were integrated into maize-based crop rotations, aligning with findings reported by Gadermaier *et al.* (2011) and Thakur and Sidar (2017). This suggests that incorporating leguminous crops into crop rotations can contribute to enhanced soil carbon content, offering potential benefits for soil fertility and overall ecosystem health, as indicated by multiple studies.

Available NPK (kg ha^{-1})

The study outcomes propose that there were no statistically significant impacts on the levels of available nitrogen, phosphorus, and potassium (NPK) arising from either individual or combined effects of tillage and weed management strategies. In contradistinction to the initial soil fertility condition, a noticeable decline was observed in the levels of available nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) at the culmination of the field experiment, especially after the maize harvest in 2019. This decline was attributed to nutrient uptake by the maize crop, weeds, in-situ cowpea, leaching losses, volatilization losses, and nutrient fixation in the soil. These findings are consistent with the results documented by Kumar (2019) and Moasunep *et al.* (2019). When comparing reduced tillage (RT) with conventional tillage (CT), it was observed that the former exhibited higher nutrient content, including N, P, and K. In CS, the concentrations of soil organic carbon (SOC) and other nutrients were notably higher compared to CT. This suggests that the conservation system (CS) could be an effective approach to enhance soil productivity in this sub-tropical ecosystem by promoting improvements in soil structure.

This improvement paves the way for the protection of soil organic matter (SOM) and nutrients, ultimately maintaining a higher nutrient content. The findings of this investigation align with those reported by Chaudhary *et al*. (2018) and Mohanty *et al*. (2015).

Soil Microflora

A higher microbial population was noticed with reduced tillage which might be due to fewer disturbances to soil. The lowest microbial population was registered in conventional tillage where more tillage practices were permitted. Disturbance to soil resulted in the degradation of the microbial population. Intensive tilling of soils diminishes soil organic matter stocks by unmasking the previously protected organic matter to microbial decomposition. There has already been evidence of a connection between the microbial population and SOM (Thomas *et al*., 2007). Within weed management strategies, maize intercropped with cowpea and the weedy check exhibited a higher microbial population than other herbicidal treatments. This can be attributed to the absence of herbicide toxicity and favorable conditions for microbial growth, facilitated by organic matter addition through leaf fall and root exudates from cowpeas. It is important to highlight that herbicides, particularly when applied at higher concentrations, tend to persist in the soil, exerting toxic effects on microorganisms. This persistence results in a decline in the abundance, activity, and, subsequently, the diversity of microbial communities (Lavanya, 2021).

Soil Dehydrogenase Enzymatic Activity

Reduced tillage produced higher dehydrogenase activity due to increased organic carbon content, which influences microbial mass. Conventional tillage has been shown to diminish soil microbiological activity and aggregate stability (Bayer *et al*., 2001), leading to a swift decline in Soil Organic Matter (SOM) and dehydrogenase enzymatic activity (Acosta-Martinez *et al*., 2003). The application of herbicide spraying has an impact on soil enzymatic activity. Specifically, treatments involving herbicides exhibited lower dehydrogenase activity compared to alternative treatments. This could be attributed to herbicides causing osmotic stress which inhibited the survival of micro-organisms (Bharati *et al*., 2020). Higher dehydrogenase activity in the legume-based intercropping systems is attributed to increased organic carbon, which stimulated microbial activity. The findings of our study align with the results of Bajaj *et al*. (2019), Tao *et al*. (2009), and Velmourougane *et al*. (2013).

CONCLUSION

The outcome of the study suggests that the individual and combined influences of tillage and weed management strategies on soil physicochemical properties in maize did not exhibit statistically significant differences. The comparison between the CT and RT did not consistently show significant differences in terms of soil microbial mass and dehydrogenase activity across the studied conditions. The study found that weed management strategies in maize cultivation significantly affected both the soil microbial biomass and dehydrogenase activity. This indicates that the specific methods used to manage weeds in the context of maize cultivation played a discernible role in influencing the volume of microbial biomass and the activity of dehydrogenase in the soil. The results highlight the importance of considering weed management strategies as a significant factor in shaping these particular soil properties in maize farming. Importantly, it is noteworthy that the study did not find any statistically significant interaction between tillage and weed management strategies concerning soil microbial mass and dehydrogenase activity.

Table 1: Physico-chemical and biological properties of the experimental site (0-15 cm) before sowing of the crop

S.No	Particulars	Value	Method
A.	**Physical characteristics**		
1	Sand (%)	43.52	Bouyoucos hydrometer method (Piper,1966)
	Silt (%)	19.28	
	Clay (%)	37.20	
	Textural class	Clay loam	USDA textural triangle
2	Bulk density (g cm^{-3})	1.42	Dhakshinamurthy and Gupta (1968)
B.	**Chemical characteristics**		
1	Organic carbon (%)	0.37	Rapid titration method (Walkley and Black, 1934)
2	Available nitrogen (kg ha^{-1})	228	Alkaline $KMnO_4$ method Subbiah and Asija (1956)
3	Available P_2O_5 (kg ha^{-1})	23	Olsen's method for extraction and Ascorbic acid method for estimation by using Spectrophotometer at 420 nm (Olsen *et al*., 1954)
4	Available K_2O (kg ha^{-1})	405	Neutral normal ammonium acetate method using ELICO CL 378 Flame photometer (Jackson, 1973)
5	pH (1:2.5) Soil: water suspension	7.91	pH meter (Jackson, 1973)
6	E.C. (dSm^{-1})	0.30	EC meter (Jackson, 1973)
C	**Biological analysis**		
1	Fungi (CFU × 10^4 g^{-1} of soil)	18.10	Nutrient agar (Collins and Lyne, 1968)
2	Bacteria (CFU × 10^6 g^{-1} of soil)	30.44	Martins rose Bengal agar (Martin, 1950)
3	Actinomycetes (CFU × 10^3 g^{-1} of soil)	22.02	Kenknight's medium (Kenknight and Muncie, 1939)
4	Dehydrogenase activity (µg TPF formed g^{-1} soil day^{-1})	10.67	Casida *et al*. (1964)

Table 2: Tillage practices adopted in maize crop

Treatments	No. of tillage operations	Tillage implement	Timing of tillage operations
Conventional tillage (CT)	1	Cultivator	Summer season
	1	Cultivator	Before sowing
	1	Rotavator	Before sowing
Reduced tillage (RT)	1	Cultivator	Before sowing
	1	Blade harrow	Before sowing

Table 3: Effect of tillage and weed management strategies on soil bulk density, pH, EC and OC after the harvest of maize

Treatments	Bulk density (g cm^{-3})		pH		EC (dSm^{-1})		OC (%)	
	2018	2019	2018	2019	2018	2019	2018	2019
Vertical plots : Tillage practices (T)								
T_1	1.43	1.44	7.88	7.86	0.31	0.32	0.35	0.36
T_2	1.45	1.48	7.84	7.78	0.32	0.33	0.36	0.38
SE(m)±	0.02	0.01	0.05	0.09	0.004	0.004	0.006	0.04
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	4.87	5.90	2.97	5.58	5.43	5.26	7.71	5.33
Horizontal plots : Weed management (W)								
W_1	1.44	1.45	7.83	7.79	0.31	0.32	0.36	0.38
W_2	1.43	1.44	7.88	7.84	0.30	0.31	0.34	0.35
W_3	1.44	1.44	7.83	7.79	0.32	0.33	0.37	0.39
W_4	1.43	1.46	7.88	7.84	0.31	0.32	0.35	0.36
W_5	1.46	1.47	7.89	7.85	0.32	0.33	0.35	0.36
W_6	1.44	1.49	7.87	7.83	0.31	0.32	0.35	0.36
W_7	1.45	1.48	7.86	7.82	0.32	0.32	0.36	0.37
SE(m)±	0.03	0.02	0.07	0.11	0.004	0.01	0.007	0.01
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
	4.37	4.03	2.47	3.73	2.85	2.76	4.92	6.43
Interaction								
T×W								
SE(m)±	0.04	0.03	0.11	0.22	0.005	0.005	0.009	0.01
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
W×T								
SE(m)±	0.04	0.03	0.11	0.19	0.004	0.004	0.009	0.01
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 4: Effect of tillage and weed management strategies on soil available nutrient status after the harvest of maize

Treatments	Nitrogen (kg ha^{-1})		Phosphorous (kg ha^{-1})		Potassium (kg ha^{-1})	
	2018	2019	2018	2019	2018	2019
Vertical plots : Tillage practices (T)						
T_1	215	200	21.6	19.9	389	361
T_2	225	210	24.4	22.8	400	373
SE(m)±	6.00	6.27	0.72	0.69	11.93	10.79
CD (p=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	12.48	13.99	14.38	13.72	13.84	13.64
Horizontal plots : Weed management (W)						
W_1	246	227	25.8	25.1	427	399
W_2	193	175	20.4	17.1	360	332
W_3	233	215	24.0	23.1	412	385
W_4	200	192	21.7	18.2	370	341
W_5	203	195	22.0	19.3	375	346
W_6	224	208	23.1	22.0	396	372
W_7	241	224	24.1	24.4	422	395
SE(m)±	12.67	11.37	1.05	0.96	24.00	21.34
CD (p=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	14.07	13.56	11.20	10.14	14.88	14.21
Interaction						
T×W						
SE(m)±	18.48	19.58	1.47	1.37	29.92	24.19
CD (p=0.05)	NS	NS	NS	NS	NS	NS
W×T						
SE(m)±	18.41	18.17	1.44	1.32	31.86	26.99
CD (p=0.05)	NS	NS	NS	NS	NS	NS

Table 5: Effect of tillage and weed management strategies on soil micro flora after the harvest of maize

Treatments	Fungi (CFU × 10^4 g^{-1} soil)			Bacteria (CFU × 10^6 g^{-1} soil)			Actinomycetes (CFU × 10^3 g^{-1} soil)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
Vertical plots : Tillage (T)									
T_1	21.45	24.08	22.76	36.54	39.93	38.24	25.20	28.27	26.73
T_2	23.62	27.08	25.35	39.63	44.93	42.28	27.32	31.60	29.46
SE(m)±	0.47	0.53	0.48	0.73	0.93	0.83	0.53	0.64	0.58
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Horizontal plots : Weed Management (W)									
W_1	25.27	28.29	26.78	40.33	46.60	43.47	29.15	33.13	31.14
W_2	22.97	26.63	24.80	37.69	42.60	40.15	25.48	29.30	27.39
W_3	27.56	31.54	29.55	47.73	51.50	49.26	32.80	36.15	34.48
W_4	19.12	22.23	20.68	34.19	37.66	35.93	22.29	25.80	24.04
W_5	18.62	20.75	19.68	31.27	34.44	32.85	22.02	25.50	23.76
W_6	20.60	22.28	21.44	36.34	40.02	38.18	23.66	27.30	25.48
W_7	23.59	27.34	25.46	39.34	44.60	41.97	28.43	32.35	30.39
SE(m)±	0.78	0.88	0.78	1.42	1.58	1.45	0.91	1.09	0.97
CD (p=0.05)	2.40	2.72	2.97	4.40	3.87	4.46	2.80	3.36	2.99
CV (%)	8.50	8.46	9.31	9.19	9.13	8.82	8.50	8.92	8.46
Interaction									
T×W									
SE(m)±	1.03	1.15	1.04	1.64	2.21	1.73	1.20	1.53	1.32
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
W×T									
SE(m)±	1.04	1.18	1.05	1.81	2.20	1.85	1.22	1.53	1.32
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 6: Effect of tillage and weed management strategies on soil dehydrogenase (µg TPF formed g^{-1} soil day^{-1}) after the harvest of maize

Treatments	Soil dehydrogenase (µg TPF formed g^{-1} soil day^{-1})		
	2018	2019	Pooled
Vertical plots : Tillage (T)			
T_1	10.82	12.43	11.63
T_2	12.10	14.50	13.30
SE(m)±	0.26	0.34	0.28
CD (p=0.05)	NS	NS	NS
Horizontal plots : Weed Management (W)			
W_1	13.47	16.81	15.14
W_2	12.33	14.52	13.42
W_3	16.25	20.47	18.36
W_4	8.32	9.53	8.92
W_5	7.87	8.49	8.18
W_6	8.81	10.01	9.41
W_7	13.19	14.45	13.82
SE(m)±	0.59	0.57	0.60
CD (p=0.05)	1.83	1.78	1.85
CV (%)	12.70	10.53	11.80
Interaction			
T×W			
SE(m)±	0.64	0.79	0.71
CD (p=0.05)	NS	NS	NS
W×T			
SE(m)±	0.74	0.79	0.78
CD (p=0.05)	NS	NS	NS

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