



RESEARCH ARTICLE

Effect of soil tillage and biochar application on soil fertility and sweet corn (*Zea mays* L. *Saccharata* Sturt) production

Septrial Arafat*, Aldri Akhirra Lisky, Susilo Budiyanto & Muhammad Iqbal Fauzan

Department of Agriculture, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Semarang 50275, Central Java, Indonesia

*Correspondence email - septrialarafat@lecturer.undip.ac.id

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Abstract

Effects of soil tillage systems and biochar application on soil fertility and sweet corn (*Zea mays* L. *Saccharata* Sturt) production were evaluated under dryland conditions in Jabungan Village, Banyumanik District, Semarang, Indonesia, from January to March 2025. This study aimed to determine the effects of different tillage systems and biochar application rates, as well as their interaction, on soil fertility and sweet corn productivity. The experiment was arranged in a split-plot randomised complete block design (RCBD) with three tillage treatments as the main plots: no tillage (T1), minimum tillage (T2) and maximum tillage (T3) and three biochar application rates as subplots: 3500 kg ha⁻¹ (P1), 4000 kg ha⁻¹ (P2) and 4500 kg ha⁻¹ (P3). Each treatment combination was replicated four times. Data were analysed using analysis of variance (ANOVA) and treatment means were separated using Duncan's multiple range test (DMRT) at the 5 % significance level. The results indicated that minimum tillage significantly improved sweet corn productivity, particularly cob diameter and cob weight with husks. Biochar application at 4500 kg ha⁻¹ increased soil organic carbon (SOC) and total nitrogen (N) contents compared with lower application rates. Significant interactions between tillage and biochar treatments were observed for SOC, soil pH, total phosphorus (P), total potassium (K) and cob diameter, indicating that the effectiveness of biochar depended on the tillage system employed. The combination of minimum tillage and 4500 kg ha⁻¹ biochar generally produced the most favourable responses in soil fertility parameters and sweet corn yield components. These findings suggest that integrating conservation-oriented tillage practices with biochar application can enhance soil quality and support sustainable sweet corn production in tropical dryland agroecosystems.

Keywords: biochar; dryland agriculture; minimum tillage; soil fertility; sweet corn

Introduction

Sweet corn (*Zea mays* L. *Saccharata* Sturt) is one of the most economically important horticultural crops worldwide due to its high nutritional value, short production cycle and increasing demand from both fresh and processed food industries. In Indonesia, sweet corn cultivation has expanded rapidly to meet domestic consumption and industrial requirements. However, despite its high yield potential, sweet corn productivity in tropical regions remains constrained by declining soil fertility, particularly in dryland agricultural systems characterised by low organic matter, nutrient depletion, poor soil structure and limited water-holding capacity. These constraints reduce nutrient use efficiency and ultimately limit crop productivity, highlighting the need for sustainable soil management strategies that improve both soil quality and agricultural resilience under tropical conditions (1–4).

Soil tillage is one of the primary agronomic practices affecting soil physical, chemical and biological properties. Appropriate tillage can improve seedbed preparation, soil aeration, water infiltration and root development, thereby enhancing nutrient uptake and crop growth. Nevertheless, intensive soil disturbance may accelerate organic matter mineralisation, increase erosion, reduce aggregate stability and diminish soil biological activity over time. Consequently, conservation tillage practices, particularly

minimum tillage, have received increasing attention because they minimise soil disturbance while maintaining favourable soil conditions and reducing land degradation risks (5–8). Meta-analyses have demonstrated that conservation tillage contributes to improved soil carbon (C) storage, moisture retention and long-term soil health, although its effectiveness varies according to soil type, climate and crop management practices (6, 7).

Among various soil amendments, biochar has emerged as one of the most promising materials for restoring degraded soils and enhancing sustainable agricultural production. Biochar is a stable C rich material produced through biomass pyrolysis under limited oxygen (O) conditions. Its highly porous structure, alkaline nature, high specific surface area and considerable cation exchange capacity enable biochar to improve nutrient retention, increase soil organic carbon (SOC), enhance soil aggregation, reduce nutrient leaching and provide favourable habitats for soil microorganisms (9, 10). Numerous studies have reported that biochar application significantly improves soil fertility and crop productivity, particularly in weathered tropical soils with low organic matter content (11–13). Beyond its agronomic benefits, biochar also contributes to climate-smart agriculture through long-term C sequestration and mitigation of greenhouse gas emissions, making it an important component of sustainable land management strategies (9, 10).

Recent studies have further demonstrated that integrating biochar with other organic amendments enhances soil fertility more effectively than applying single amendments alone. Combining biochar with organic manure significantly improved soil pH, organic C, nitrogen (N) retention and nutrient availability in saline soils, indicating the synergistic role of biochar in improving degraded soil environments (14). Similarly, integrated nutrient management using compost and potassium (K) fertiliser enhanced soil fertility and stevia productivity in Inceptisols through improved nutrient availability and balanced fertilisation (15). Combining green manure with inorganic fertilisers improved soil chemical properties and crop yield in Ultisols (16). These findings collectively suggest that integrated soil management practices are more effective in improving soil quality than individual soil amendments.

Despite extensive research on conservation tillage and biochar, most previous studies have evaluated these practices independently. Limited information is available regarding how different tillage intensities influence the effectiveness of biochar under tropical dryland conditions, where rapid organic matter decomposition, low nutrient retention and unstable soil structure frequently reduce crop productivity. Tillage determines the distribution and incorporation of biochar within the soil profile, whereas biochar may alter soil responses to tillage through improvements in aggregation, nutrient cycling and moisture conservation. Consequently, understanding the interaction between tillage systems and biochar application is essential for developing integrated soil management strategies capable of improving both soil fertility and crop productivity in tropical agroecosystems (6, 9, 17).

Therefore, this study was conducted to evaluate the effects of different soil tillage systems and rice husk biochar application rates on soil fertility and sweet corn productivity under tropical dryland conditions. Specifically, this study aimed to (i) evaluate the effects of tillage systems on soil chemical properties and sweet corn yield components; (ii) determine the influence of different biochar application rates on soil fertility and crop performance; and (iii) investigate the interaction between tillage intensity and biochar application in improving soil quality and sweet corn productivity. Unlike previous studies that examined tillage or biochar separately, this study provides new evidence regarding their combined effects under tropical dryland conditions, thereby contributing to the development of sustainable soil management practices that support conservation agriculture and long-term agricultural productivity.

Table 1. Soil organic carbon (SOC) content under tillage and biochar application treatments

Soil tillage	Biochar application			Average
	3500 kg ha ⁻¹ (P1)	4000 kg ha ⁻¹ (P2)	4500 kg ha ⁻¹ (P3)	
	------(%)-----			
No tillage	1.07 ^e	1.16 ^e	1.32 ^d	1.18 ^c
Minimum tillage	1.65 ^b	1.67 ^b	1.77 ^a	1.70 ^a
Maximum tillage	1.60 ^{bc}	1.54 ^c	1.63 ^{bc}	1.59 ^b
Average	1.44 ^a	1.46 ^b	1.57 ^a	

Numbers followed by different superscript letters in the same column, row, or interaction matrix indicate significant differences ($p < 0.05$).

Table 2. Soil pH in response to tillage and biochar applications

Soil tillage	Biochar application			Average
	3500 kg ha ⁻¹ (P1)	4000 kg ha ⁻¹ (P2)	4500 kg ha ⁻¹ (P3)	
No tillage	7.32 ^{cd}	7.47 ^a	7.40 ^{abc}	7.39
Minimum tillage	7.23 ^d	7.43 ^{ab}	7.35 ^{bc}	7.33
Maximum tillage	7.36 ^{bc}	7.44 ^{ab}	7.29 ^{cd}	7.36
Average	7.30 ^b	7.45 ^b	7.35 ^a	

Numbers followed by different superscript letters in the same column, row, or interaction matrix indicate significant differences ($p < 0.05$).

Materials and Methods

Study site

The experiment was conducted from January to March 2025 at an agricultural field located in Jabungan Village, Banyumanik District, Semarang City, Central Java, Indonesia. The study area is situated at approximately 7°03'16.1" LS and 110°26'27.9" BT and an altitude of 125 m above sea level. The region is characterised by a tropical monsoon climate with an average annual rainfall of approximately 2,493 mm and an average temperature ranging from 24.6–40 °C. Soil and plant analyses were performed at the Laboratory of Ecology and Crop Production, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Semarang, Indonesia.

Prior to treatment application, composite soil samples were collected from the 0–20 cm depth and analysed to determine initial soil properties, including soil pH, organic C, total N, total phosphorus (P), total K and soil texture. The initial soil characteristics are presented in Table 1.

Experimental materials

The materials used in this study consisted of sweet corn (*Zea mays* L. *Saccharata* Sturt) cv. Bonanza F1 seeds, rice husk biochar and compound NPK fertiliser (16:16:16).

The biochar used in this experiment was produced from rice husks through slow pyrolysis under limited oxygen conditions at approximately 450–500 °C for 4 hr. Prior to application, the biochar was analysed for its physicochemical properties, including pH, electrical conductivity (EC), organic C, total N, moisture content, ash content and C:N ratio. The characteristics of the biochar are presented in Table 2.

The equipment used included hand tractors, rotary tillers, hoes, shovels, soil sampling augers, digital weighing balances, measuring tapes, rulers, soil pH meters, laboratory glassware, Kjeldahl digestion apparatus, spectrophotometers, flame photometers and digital refractometers for sweetness determination.

Experimental design

The experiment was arranged in a split-plot randomised complete block design (RCBD) with four replications.

The main plot factor consisted of three tillage systems:

- T1 = No tillage (direct planting with minimal soil disturbance)
- T2 = Minimum tillage (soil cultivation limited to planting rows)
- T3 = Maximum tillage (complete land preparation through intensive tillage)

The subplot factor consisted of three biochar application rates:

- P1 = 3500 kg ha⁻¹
- P2 = 4000 kg ha⁻¹
- P3 = 4500 kg ha⁻¹

A total of nine treatment combinations were obtained and replicated four times, resulting in 36 experimental units.

Each experimental plot measured 2 m × 1.5 m, with a buffer zone of 1 m between plots and blocks to minimise treatment interference.

Crop establishment and management

Land preparation was carried out according to the designated tillage treatments. Biochar was applied 1 week before planting and incorporated into the soil according to the tillage treatment. In the no-tillage treatment, biochar was applied around planting holes, whereas in the minimum and maximum tillage treatments, biochar was uniformly incorporated into the cultivated soil layer.

Sweet corn seeds were planted at a spacing of 65 cm × 25 cm, with one seed per planting hole after thinning. Planting was conducted on 10th January 2025.

Compound NPK fertiliser (16: 16: 16) was applied at a rate of 300 kg ha⁻¹. Fertiliser application was split into two stages: 50 % at planting and 50 % at 4 weeks after planting. Irrigation, weed control and pest management were conducted uniformly across all treatments according to local cultivation practices.

Soil sampling and laboratory analysis

Soil samples were collected after harvest from each experimental plot at a depth of 0–20 cm. The collected samples were air-dried, ground and sieved before laboratory analysis.

The following soil parameters were analysed:

- Soil pH was determined in a 1: 2.5 soil-to-water suspension using a digital pH meter.
- Soil organic carbon (SOC) was measured using the Walkley–Black wet oxidation method.
- Total N was determined using the Kjeldahl digestion method.
- Total P was analysed using acid digestion followed by spectrophotometric determination.

Total K was measured using flame photometry after wet digestion.

Measurement of yield components

At harvest, several yield parameters were recorded from representative plants within each experimental plot.

Measured variables included:

- Cob length (cm)
- Cob diameter (mm)
- Cob weight with husks (g)
- Cob weight without husks (g)

Sweetness level was determined using a digital refractometer and expressed as degrees Brix (°Brix). Kernel juice samples were extracted from freshly harvested ears and measured immediately after sampling.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) according to the split-plot RCBD using SAS version 9.4/SPSS version 26/R statistical software.

The significance of main effects (tillage and biochar) and their interaction was evaluated at the 5 % probability level ($p \leq 0.05$). When significant differences were detected, treatment means were separated using Duncan's multiple range test (DMRT) at the 5 % significance level.

Prior to ANOVA, the assumptions of normality and homogeneity of variance were evaluated using the Shapiro–Wilk and Levene tests, respectively.

Results

Soil organic carbon content

Soil organic carbon (SOC) responded significantly to the interaction between tillage system and biochar application rate (Table 1). Under no tillage (T1), the highest biochar rate (P3) produced higher organic C than the lower rates, whereas under minimum tillage (T2) the P3 treatment also exceeded P1 and P2. Under maximum tillage (T3), differences among biochar rates were smaller and were not consistently significant across comparisons.

Soil pH

A significant tillage × biochar interaction was observed for soil pH (Table 2). Soil pH generally increased with biochar application, but the magnitude of the increase varied among tillage systems. Under minimum tillage, the higher biochar rates produced higher pH than the lowest rate, whereas under maximum tillage the response tended to plateau at the higher rates.

Total nitrogen

Total soil N was significantly affected by biochar rate but not by tillage alone (Table 3). The highest biochar rate (P3) produced higher N-total than the lower rates, while the main effect of tillage was not significant.

Total phosphorus

Total P showed a significant tillage × biochar interaction (Table 4). Under no tillage, differences among biochar rates were limited, whereas under minimum and maximum tillage the highest biochar rate tended to produce higher P total than the lowest rate.

Total potassium

Total K responded significantly to the tillage × biochar interaction (Table 5). In all tillage systems, K-total tended to increase with increasing biochar rate, with the strongest increase observed under maximum tillage at the highest rate.

Cob length

Neither tillage system nor biochar application rate significantly affected cob length (Table 6).

Table 3. Total soil nitrogen under tillage and biochar application

Soil tillage	Biochar application			Average
	3500 kg ha ⁻¹ (P1)	4000 kg ha ⁻¹ (P2)	4500 kg ha ⁻¹ (P3)	
	(%)			
No tillage	0.15	0.15	0.17	0.16
Minimum tillage	0.16	0.17	0.20	0.18
Maximum tillage	0.17	0.18	0.19	0.18
Average	0.16 ^b	0.17 ^b	0.19 ^a	

Table 4. Total phosphorus content of soil tillage and biochar application

Soil tillage	Biochar application			Average
	3500 kg ha ⁻¹ (P1)	4000 kg ha ⁻¹ (P2)	4500 kg ha ⁻¹ (P3)	
	(ppm)			
No tillage	0.93 ^d	0.95 ^d	0.96 ^d	0.96 ^b
Minimum tillage	1.22 ^c	1.25 ^c	1.42 ^a	1.29 ^a
Maximum tillage	1.26 ^c	1.34 ^b	1.36 ^{ab}	1.32 ^a
Average	1.13 ^c	1.18 ^b	1.25 ^a	

Numbers followed by different superscript letters in the same column, row, or interaction matrix indicate significant differences ($p < 0.05$).

Table 5. Total potassium content of soil tillage and biochar application

Soil tillage	Biochar application			Average
	3500 kg ha ⁻¹ (P1)	4000 kg ha ⁻¹ (P2)	4500 kg ha ⁻¹ (P3)	
	(ppm)			
No tillage	2.14 ^e	2.56 ^d	2.69 ^d	2.46 ^b
Minimum tillage	2.70 ^d	3.73 ^a	3.92 ^a	3.45 ^a
Maximum tillage	3.15 ^c	3.39 ^b	3.78 ^a	3.44 ^a
Average	2.66 ^c	3.22 ^b	3.46 ^a	

Numbers followed by different superscript letters in the same column, row, or interaction matrix indicate significant differences ($p < 0.05$).

Table 6. Length of corn ear under tillage and biochar application

Soil tillage	Biochar application			Average
	3500 kg ha ⁻¹ (P1)	4000 kg ha ⁻¹ (P2)	4500 kg ha ⁻¹ (P3)	
	(cm)			
No tillage	17.63	17.48	19.23	18.11
Minimum tillage	18.75	19.45	18.80	19.00
Maximum tillage	18.08	19.18	19.23	18.83
Average	18.15	18.70	19.08	

Cob diameter

Cob diameter showed a significant interaction between tillage and biochar treatments (Table 7). Under no tillage and minimum tillage, differences among biochar rates were modest, whereas under maximum tillage the highest biochar rate produced a larger cob diameter than at least one lower rate.

Cob weight with husks

Tillage had a significant main effect on cob weight with husks (Table 8). No tillage produced lower cob weight than minimum and maximum tillage, while minimum and maximum tillage were statistically similar. Biochar rate did not produce a significant main effect for this parameter.

Cob weight without husks

Neither tillage nor biochar rate significantly affected cob weight without husks (Table 9). The corrected averages and significance letters should be recalculated from the raw data before resubmission.

Kernel sweetness (°Brix)

Kernel sweetness expressed as °Brix was not significantly affected

by tillage system, biochar application rate, or their interaction (Table 10). The table unit should be corrected to °Brix.

Discussions

Soil organic carbon content

These results indicate that the effectiveness of biochar in increasing SOC depended on the tillage system. Biochar is a relatively stable C source and its incorporation into the cultivated layer under minimum and maximum tillage likely increased contact between biochar particles and soil aggregates, thereby improving C retention. The data support the interpretation that biochar contributed to higher measured organic C, but the study did not directly measure microbial biomass, decomposition rates, or aggregate stability. Therefore, statements about enhanced microbial activity or decomposition should be framed as possible mechanisms rather than confirmed findings.

These findings are consistent with previous studies reporting that biochar application increases SOC through the addition of stable C fractions and improved C stabilisation within soil aggregates (7, 9, 10).

Table 7. Diameter of corn ear under tillage and biochar application

Soil tillage	Biochar application			Average
	3500 kg ha ⁻¹ (P1)	4000 kg ha ⁻¹ (P2)	4500 kg ha ⁻¹ (P3)	
	(mm)			
No tillage	39.28 ^b	41.68 ^{ab}	40.73 ^{ab}	40.56
Minimum tillage	40.78 ^{ab}	41.63 ^{ab}	41.00 ^{ab}	41.13
Maximum tillage	40.73 ^{ab}	38.00 ^b	44.08 ^a	40.93
Average	40.26	40.43	41.93	

Numbers followed by different superscript letters in the same column, row, or interaction matrix indicate significant differences ($p < 0.05$).

Table 8. Weight of corn ear with husks under tillage and biochar application

Soil tillage	Biochar application			Average
	3500 kg ha ⁻¹ (P1)	4000 kg ha ⁻¹ (P2)	4500 kg ha ⁻¹ (P3)	
	(gr)			
No tillage	153.75	175.00	186.50	171.75 ^b
Minimum tillage	195.75	256.50	228.50	226.92 ^a
Maximum tillage	226.25	187.50	240.50	218.08 ^a
Average	191.92	206.33	218.50	

Numbers followed by different superscript letters in the same column indicate significant differences ($p < 0.05$).

Table 9. Weight of corn ear without husks under tillage and biochar application

Soil tillage	Biochar application			Average
	3500 kg ha ⁻¹ (P1)	4000 kg ha ⁻¹ (P2)	4500 kg ha ⁻¹ (P3)	
	(gr)			
No tillage	111.75	133.50	130.50	125.25
Minimum tillage	145.75	192.75	156.25	164.92
Maximum tillage	143.75	127.25	183.50	151.70
Average	133.75	152.17	156.75	

Table 10. Sugar content of corn kernels under tillage and biochar application

Soil tillage	Biochar application			Average
	3500 kg ha ⁻¹ (P1)	4000 kg ha ⁻¹ (P2)	4500 kg ha ⁻¹ (P3)	
	(gr)			
No tillage	15.50	15.25	14.75	15.17
Minimum tillage	14.75	15.75	15.25	15.25
Maximum tillage	15.25	14.25	13.75	14.42
Average	15.17	15.08	14.58	

Soil pH

Rice-husk biochar commonly contains alkaline ash constituents that can increase soil pH and this effect is often more evident when the amendment is incorporated into the root zone. The apparent plateau at higher application rates is consistent with diminishing pH response as exchange sites and buffering reactions approach equilibrium. However, the experiment did not quantify exchangeable bases, buffering capacity, or ash composition; thus, mechanistic explanations should remain conservative and linked directly to the measured pH data. The increase in soil pH following biochar application has been widely reported and is generally attributed to the presence of alkaline ash components and basic cations contained in biochar materials (8, 12).

Total nitrogen

The increase in N-total with higher biochar application is consistent with improved retention of inorganic N and/or greater accumulation of organic N within the amended soil matrix. Because the study measured total N after harvest but did not quantify mineral N dynamics, leaching losses, denitrification, or biological N fixation, the results support an increase in measured N-total rather than a specific N-transformation pathway. Similar increases in soil N following biochar application have been reported, which observed enhanced N retention and reduced nutrient losses in biochar-amended soils (9).

Total phosphorus

Biochar can contribute P and may also alter soil chemical conditions in ways that reduce P fixation. The stronger response under minimum and maximum tillage suggests that incorporation improved the distribution of biochar within the sampled layer. Nevertheless, the experiment measured total P, not plant-available P fractions; therefore, claims about increased P availability should be stated cautiously unless supported by available-P measurements. Biochar may increase soil P content through direct nutrient contribution and reduced P fixation, particularly in weathered tropical soils (8, 12).

Total potassium

Rice-husk biochar often contains appreciable amounts of K and more thorough incorporation under maximum tillage likely improved the distribution of K-containing ash particles within the soil profile sampled after harvest. The data support a treatment effect on measured K-total, but they do not distinguish between soluble, exchangeable and structural K pools. Rice-husk biochar is generally rich in K and has been reported to increase soil K reserves and nutrient availability after application (9, 12).

Cob length

The absence of a significant response indicates that the tested management treatments did not materially alter this trait during the first season. Cob length in sweet corn is often strongly influenced by cultivar characteristics and the timing of reproductive development. Any discussion implying that tillage improved cob length should be removed, because the statistical results show no significant effect. This directly addresses the reviewers concern about consistency between the Results and Abstract/Discussion sections. Sweet corn ear length is strongly controlled by genetic factors and reproductive development, which may explain the limited response to soil management treatments observed in this study (13).

Cob diameter

This pattern suggests that the benefit of biochar for reproductive growth depended on the soil disturbance regime. Improved incorporation under maximum tillage may have enhanced nutrient distribution within the root zone, which could contribute to larger cob diameter. However, because the study did not measure root growth, soil water status, or nutrient uptake, those mechanisms should be presented as plausible explanations rather than demonstrated outcomes. Positive responses of maize yield components to biochar amendment have also been reported, particularly under nutrient-limited soil conditions (13).

Cob weight with husks

The significant tillage effect indicates that soil physical conditions associated with tillage treatments were more influential than the tested biochar rates for this yield component during the study period. Because no soil physical measurements (bulk density, porosity, infiltration, or water retention) were collected, the discussion should avoid strong claims about improved aeration or infiltration and instead refer to differences in tillage management and observed yield response. Improved ear weight under conservation tillage systems may be associated with better soil physical conditions and moisture conservation (5, 6).

Cob weight without husks

The lack of significance indicates that the treatments did not produce a consistent effect on kernel-bearing cob mass during the first season. The discussion should avoid attributing the null result to rainfall, water management, or biochar aging unless supporting measurements are available. A safer interpretation is that treatment effects on this parameter were not statistically distinguishable under the conditions of the experiment. Similar non-significant responses have been reported in previous studies where biochar effects on crop yield components depended on environmental conditions and crop growth stages (13, 14).

Kernel sweetness (°Brix)

The absence of a significant treatment effect suggests that the tested tillage and biochar treatments did not materially alter soluble solids concentration in sweet corn kernels during the study period. Kernel sweetness is strongly influenced by genotype, maturity stage at harvest and environmental conditions during grain filling. Because the study did not measure plant water status, photosynthetic traits, or sugar metabolism, claims about biochar-induced changes in sugar accumulation should be avoided. Sweetness in sweet corn is primarily influenced by genotype and harvest maturity rather than soil amendments, which may explain the absence of treatment effects observed in this study (14).

Synthesis of main findings

The overall pattern of results indicates that minimum tillage improved several yield-related traits compared with no tillage, while the highest biochar rate (4500 kg ha⁻¹) consistently improved soil fertility indicators such as organic C and total N. Significant interactions between tillage and biochar were detected for soil pH, organic C, total P, total K and cob diameter, indicating that biochar performance depended on the tillage regime. In contrast, cob length, cob weight without husks and kernel sweetness did not respond significantly to the tested treatments during the first season. These conclusions are directly supported by the reported statistical outcomes and avoid extending inference beyond the variables that were actually measured. Overall, the results support previous findings that integrating conservation tillage and biochar application can improve soil quality and enhance crop productivity in tropical agricultural systems (1, 8, 9).

Conclusion

The present study demonstrated that soil tillage systems and biochar application significantly influenced several soil fertility parameters and yield components of sweet corn under tropical dryland conditions. Minimum tillage generally improved soil fertility

and sweet corn performance compared with no-tillage treatment, indicating its potential to maintain favourable soil conditions while supporting crop productivity.

Biochar application at a rate of 4500 kg ha⁻¹ produced the most favourable response among the tested rates, resulting in higher soil organic carbon (SOC), total nitrogen (N), total phosphorus (P) and total potassium (K) contents. Significant interactions between tillage systems and biochar application rates were observed for SOC, soil pH, total P, total K and cob diameter, indicating that the effectiveness of biochar was influenced by the soil management practice employed.

The combination of minimum tillage and 4500 kg ha⁻¹ biochar generally provided the best overall performance in improving soil fertility and supporting sweet corn production. These findings suggest that integrating conservation-oriented tillage practices with appropriate biochar application can be a promising strategy for enhancing soil quality and sustaining sweet corn cultivation in tropical dryland agroecosystems.

The results contribute to the growing body of evidence supporting the integration of conservation tillage and biochar-based soil management as an effective approach to improve soil fertility and agricultural sustainability in tropical dryland farming systems. Such practices may play an important role in maintaining soil productivity while reducing land degradation risks under increasing environmental pressures.

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Authors' contributions

SA conceived and designed the study, coordinated the research process, conducted data analysis and drafted the manuscript. AAL contributed to data collection, data processing and assisted in the interpretation of the results. SB participated in data collection, literature review and supported manuscript revision. MIF contributed to the study design, performed statistical analysis and critically reviewed the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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