TIMBOU-AFRICA PUBLICATION INTERNATIONAL JOURNAL AUGUST, 2025 EDITIONS.

INTERNATIONAL JOURNAL OF AGRICULTURAL RESEARCH AND BIOTECHNOLOGY
VOL. 9 NO. 1 E-ISSN 3027-2610 P-ISSN 3027-0847

EVALUATION OF RESIDUAL EFFECTS OF LAND CLEARING AND SOIL AMENDMENT TECHNIQUES ON SOIL PROPERTIES AND TOMATO PRODUCTIVITY IN OZORO, DELTA STATE, NIGERIA

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DOI: https://doi.org/10.70382/tijarbt.v09i1.015

ABSTRACT

The long-term effects of land clearing and soil amendments on soil fertility and crop productivity remain underexplored in Nigeria. This study evaluated the residual influence of five land clearing methods (slash-and-burn, slash-and-mulch, mechanical ploughing, herbicide application, and manual residue packing) and five soil amendments (cattle dung, egusi-melon cover crop, NPK fertilizer, grass clippings, and sugarcane peels) on soil properties

Introduction

Following a two-year field experiment (2023–2024) at the Department of Agronomy, Southern Delta University, Ozoro, Nigeria, this 2025 study evaluates the residual effects of different land clearing and soil amendment techniques on soil health and tomato yield. The initial treatments involved mechanical and manual land clearing combined with organic and inorganic soil amendments. In 2025, no new treatments were introduced, allowing an assessment of the sustainability and long-term benefits of the earlier practices.

Food security in tropical agro-ecosystems is strongly linked to sustainable land and soil management. Tomato (*Solanum lycopersicum*), one of the most widely cultivated crops in Nigeria, is valued for both its economic and nutritional importance. Its performance is highly influenced by soil conditions, which are in turn shaped by land clearing and soil amendment practices.

and tomato yield in Ozoro, Delta State. A split-plot randomized complete block design was carried out in 2023 and 2024, with residual effects assessed in 2025. Results showed that slash-and-mulch maintained the highest soil infiltration (82.13 mm hr^{-1}), lower bulk density (1.47 g cm^{-3}), and maximum tomato fruit weight (583.73 g $plant^{-1}$). Slash-and-burn had negative residual impacts, with higher bulk density (1.62 g cm^{-3}) and reduced yield (481.20 g $plant^{-1}$). Among soil amendments, sugarcane peels and cattle dung significantly improved organic matter (4.07% and 3.98%) and microbial biomass, translating into higher tomato yields (598.47 g $plant^{-1}$ and 583.87 g $plant^{-1}$). Correlation analysis confirmed positive associations between yield and soil organic matter, infiltration, potassium, microbial biomass, and ECEC. The study concludes that slash-and-mulch combined with organic amendments leaves beneficial residual effects on soil fertility and tomato yield, while slash-and-burn and sole mineral fertilizer application degrade soil quality. Adoption of residue management and organic amendments is recommended for sustainable tomato production in Nigeria.

Keywords: Land Clearing, Soil Fertility, Organic Amendments, Tomato Productivity, Residual Effects.

Adekiya et al. (2002) reported that slash-and-burn methods provide short-term nutrient availability through ash deposition, but this benefit is often followed by soil degradation and a decline in overall soil quality. Work and Adekiya (2023) further observed that mechanized and slash-and-burn methods exert the most adverse residual effects on soil and crop productivity, whereas manual and chemical clearing tend to have positive or neutral outcomes. Similarly, Denish et al. (2005) found that slash-mulch techniques enhance soil organic carbon (SOC) retention, improve water infiltration, and promote soil biological activity, thereby boosting tomato productivity.

Ding et al. (2024) noted that the positive effects of organic amendments often persist across multiple cropping cycles. Desta et al. (2023) further demonstrated the role of lime in mitigating aluminum toxicity, improving phosphorus availability, and enhancing base saturation, leading to sustained improvements in tomato yield. Residual benefits of slash-mulch methods on soil fertility and tomato productivity over successive cropping seasons were also highlighted by Smith and Jones (2025) and Worky and Adeyinka (2023).

Ogunkunle et al. (2022) emphasized that combining organic and mineral amendments is more effective than relying solely on mineral fertilizers, as it not only ensures stable yields but also preserves long-term soil health. Collectively, these studies underscore that while land clearing is a fundamental agronomic practice, it is often controversial due to its varied impacts on soil, crop productivity, and the environment. Land degradation resulting from inappropriate land clearing is a major threat to sustainable agriculture in the tropics. However, the long-term consequences of land clearing and soil amendments remain underexplored in the study area. However, despite numerous investigations into immediate treatment effects, the long-term or residual impacts of these practices particularly under the humid agro-ecological conditions of Delta State remain underexplored. Understanding how land-clearing and soil-amendment methods continue to influence soil properties and tomato productivity years after their application is crucial for promoting sustainable land use and food security in tropical agro-ecosystems.

Objectives of the Study

The specific objectives were to:

1. Assess the residual effects of land clearing and soil amendment techniques on tomato growth and yield in 2025.
2. Evaluate lingering improvements or degradation in soil physical, chemical, and biological properties from 2023–2024.
3. Determine whether the earlier treatments provided sustained agronomic and environmental benefits.
4. Identify technologies that promote sustainable soil health and crop productivity.

Materials and Methods

Description of the Experimental Site

This evaluation builds upon a two-year field experiment (2023–2024) conducted at the Department of Agronomy, Southern Delta University, Ozoro, Nigeria. The initial phase assessed the influence of mechanical and manual land-clearing methods combined with organic and inorganic soil amendments on soil health and tomato yield. In 2025, no new treatments were introduced, enabling an evaluation of residual effects that is, the sustained influence of earlier management practices on soil quality and tomato productivity. This approach provides insight into the long-term agronomic and environmental benefits of different land-clearing and soil-improvement technologies.

The predominant soil type is freshwater swamp soil, developed from alluvial sediments deposited in the extensive flood plains of the Niger and Cross Rivers (Egbuchua & Ojobor, 2011). The geographical coordinates and key characteristics of the study area are presented in Table 1.

Table 1. Geographical location and key characteristics of the study area

Characteristics	Ozoro
Location	Latitude: 5°32′48.912″ N Longitude: 6°13′35.364″ E
Rainfall Range	2500–3000 mm
Temperature Range	12°C–32°C
Relief	Lowland
Soil Type	Loamy sand
Vegetation	Rainforest and deltaic swamp

Collection and Preparation of Materials

The Roma F1 tomato variety used as the test crop was obtained from the West Africa Agricultural Input Dealers Association (WAIDA), Onitsha, Anambra State, Nigeria. Egusi melon was used as a cover crop, while soil amendments included cattle manure, NPK 12:12:17 fertilizer, grass clippings, and sugarcane peels. A knapsack sprayer was also utilized for pesticide and fungicide applications.

Cattle Dung

Decomposed cattle dung was collected from the SDU University Ranch. The dung was oven-dried, ground, and sieved through a 2 mm mesh for nutrient evaluation.

Grass Clippings

Grass clippings were collected from the University Stadium and surrounding environments. One hundred grams (100 g) of clippings were oven-dried at 60°C, ground, sieved through a 2 mm mesh, and analyzed for nutrient composition before application at a rate of 2.22 t/ha (Ogundare et al., 2015).

Sugarcane Peels

Two tonnes of sugarcane peels were obtained from the Hausa Market in Ozoro. A 100 g sample was oven-dried at 60°C, ground, and analyzed for nutrient composition following the procedures outlined by Okalebo et al. (2002). The material was applied at a rate of 2.22 t/ha (Ogundare et al., 2015).

Soil Sampling and Laboratory Analysis

Soil samples were collected from the 0–20 cm depth before and after the experiment and analyzed in the Agronomy Laboratory, Southern Delta University, Ozoro. The samples were air-dried, passed through a 2 mm sieve, and analyzed for selected physical, chemical, and biological properties.

Physical properties: texture, bulk density, porosity, moisture content, soil temperature, and infiltration rate.

Chemical properties: soil pH, organic carbon, total nitrogen, available phosphorus, potassium, and effective cation exchange capacity (ECEC).

Laboratory Procedures

Physical Properties

Soil texture was determined using the hydrometer method, while bulk density was measured using the core method (Okalebo et al., 2002). Total porosity was computed using a particle density of 2.65 Mg m^{-3}. Soil temperature was measured at 9:00, 12:00, and 15:00 h using a soil thermometer inserted to a depth of 10 cm, and the mean value was recorded.

Infiltration rate was determined using a double-ring infiltrometer, while moisture content was determined gravimetrically.

Chemical Properties

Soil pH (1:2.5 soil-water ratio) was measured using a Jenway 3510 pH meter (Mangale et al., 2016). Organic matter was determined using the dichromate oxidation method, while available phosphorus was analyzed colorimetrically after Bray P-1 extraction (Bray & Kurtz, 1945). Exchangeable bases (Ca, K, Mg) were extracted using ammonium acetate and measured with a flame photometer, and total nitrogen was determined using the Kjeldahl digestion method (Jackson, 1958).

Biological Properties

Soil microbial biomass was determined using the chloroform fumigation-extraction method, while soil respiration was measured based on CO_2 evolution during microbial metabolism. Fungal populations were determined using the pour plate technique (Cheesbrough, 2006). Earthworm populations were quantified by hand-sorting and counting, while weed density was recorded as the number of weeds per square meter.

Nursery Preparation

Tomato seeds were sown on a raised nursery bed at the SDU Research and Teaching Farm for four weeks. All standard nursery management practices—including watering, weeding, and shading were properly carried out before transplanting.

Treatments and Experimental Design

The experiment employed a Randomized Complete Block Design (RCBD) in a split-plot arrangement with three replications. This design was chosen because clearing methods require large experimental units, making split-plot design more suitable for testing interaction effects. Main plots: Five land-clearing methods mechanical ploughing, herbicide clearing, manual clearing and packing, manual clearing and mulching, and

TIJARBT E-ISSN 3027-2610
P-ISSN 3027-0847

manual clearing and burning. Sub-plots: Five soil amendment treatments cattle manure, cover cropping, NPK 12:12:17, grass clippings, and sugarcane peels.

The total experimental area was 2052 m^2, divided into three blocks (replicates), each containing five main plots and 25 sub-plots, totaling 75 sub-plots. Each plot measured 3.0 m × 2.0 m with 2.0 m buffers between plots and blocks. Tomato seedlings were transplanted four weeks after sowing at a spacing of 60 cm × 60 cm, with 17 plants per plot. All standard agronomic practices were observed. In 2025, residual effects of the previous treatments were evaluated without further amendments to assess sustainability of soil fertility and crop yield.

Planting, Field Maintenance, and Data Collection

Cover crops were first planted in designated plots at a spacing of 1 m × 1 m using 25 seeds per plot. Tomato seedlings were later transplanted in the evening to minimize transplant shock. Cultural practices such as hand weeding, pruning, and staking were carried out as needed. Mancozeb (80% WP) was applied at 2.5 g/L biweekly to control Phytophthora infestans and other fungal diseases, while Cypermethrin (1.2 mL/L) was sprayed when pest infestations were observed. Four plants per plot were tagged for data collection at 4, 8, and 12 weeks after transplanting (WAT). Measured parameters included:

Plant height (cm): measured from the soil surface to the plant apex using a measuring tape.

Stem girth (cm): measured with a vernier caliper.

Tap root length (cm): measured using a ruler after uprooting.

Number of fruits per plant: counted manually.

Fruit weight (g): determined using an electronic weighing balance.

Fruit yield per plant was recorded weekly and aggregated to obtain total yield per plot.

Statistical Analysis

All data on soil properties, tomato growth, and yield were subjected to analysis of variance (ANOVA) using the Statistical Analysis System (SAS, 2002). Treatment means were separated using the Least Significant Difference (LSD) test at the 0.05 probability level.

Results and Discussion

Residual Effects of Land Clearing Technologies on Soil Properties and Tomato Yield

Slash and Mulch maintained the best residual soil quality, with the highest infiltration rate (82.13 mm/hr) and moderate bulk density (1.47 g/cm^3). This translated into the highest tomato fruit weight (583.73 g/plant). In contrast, Slash and Burn increased soil compaction (bulk density 1.62 g/cm^3), reduced infiltration, and lowered microbial activity, leading to reduced tomato yield (481.20 g/plant). Manual Pack and Chemical Herbicide methods had intermediate effects: while herbicides increased residual soil moisture (23.04%), yield gains were limited due to weaker biological activity (figures, 1,2,3,4 and 5). These findings confirm previous reports (Adeoye et al., 2020) that mulching sustains residual fertility by enhancing water retention and microbial activity.

Residual Effects of Soil Amendments on Soil Properties and Tomato Yield

Among soil amendments, Sugarcane Peels and Cattle Dung produced the strongest residual benefits, enhancing soil organic matter (4.07% and 3.98%), potassium, microbial biomass, and respiration. This resulted in superior tomato fruit yields (598.47 g/plant and 583.87 g/plant, respectively). Grass Clippings had moderate effects, while Mineral Fertilizer improved nutrients but did not sustain organic matter or microbial activity. Cover Cropping had the weakest residual fertility and lowest tomato yield (figures, 6,7,8 and 9). These outcomes align with Okon et al. (2019), who highlighted the long-term fertility benefits of organic residues compared with sole mineral fertilization.

Correlation Analysis between Soil Indicators and Tomato Yield

Correlation analysis revealed that fruit weight was positively associated with infiltration rate, microbial biomass, exchangeable K, and ECEC under land clearing treatments, while negatively correlated with bulk density. For amendments, tomato yield correlated positively with soil organic matter, microbial biomass, infiltration rate, potassium, and ECEC (figures, 10,11,12, and 13). These findings confirm that soil organic matter and biological activity are key drivers of residual fertility (Ayoola & Makinde, 2017).

Implications for Sustainable Soil Management

The evidence suggests that sustainable land clearing (Slash and Mulch) and organic amendments (Sugarcane Peels, Cattle Dung) leave stronger positive residual effects on soil health and tomato yield than destructive methods like Slash and Burn or sole reliance on mineral fertilizers. Adopting such practices enhances both short-term and long-term productivity, contributing to sustainable soil management systems.

Conclusion

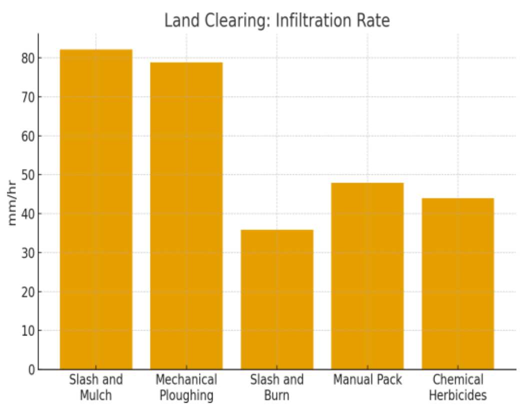
This study demonstrates that sustainable land clearing practices such as slash-and-mulch, combined with organic amendments such as sugarcane peels and cattle dung, leave strong residual benefits on soil health and tomato yield. In contrast, destructive practices such as slash-and-burn and reliance on sole mineral fertilizers degrade soil quality and reduce productivity over time.

TIJARBT E-ISSN 3027-2610
P-ISSN 3027-0847

Suggestions for Further Study

i. Evaluate the economic costs and labor requirements of each clearing method to support broader adoption.
ii. Study the long-term cumulative impact of repeated clearing cycles on soil fertility and structure.
iii. Investigate similar effects on other vegetable crops and cereals under different agro-ecological zones.

Residual Effects of Land Clearing and Soil Amendment Technologies



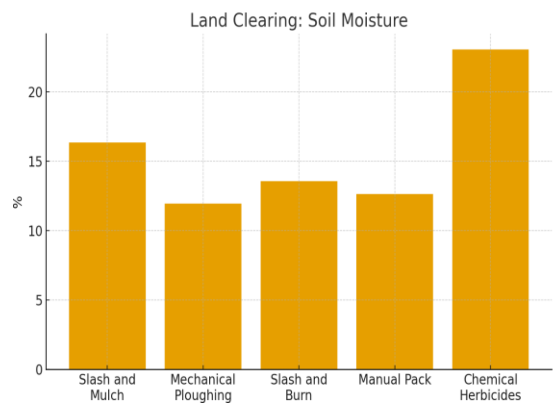
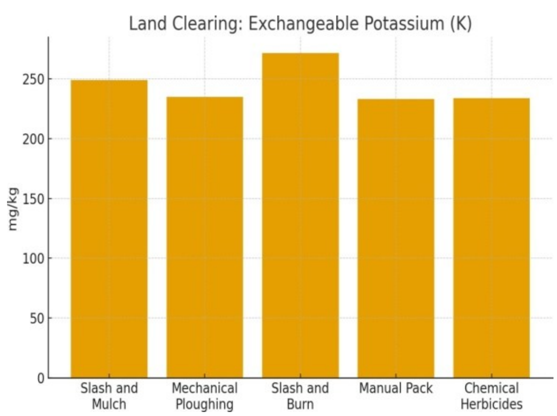


Figure 1: Land Clearing: Residual effect on soil infiltration rate.

Figure 2: Land Clearing: Residual effect on soil moisture content.



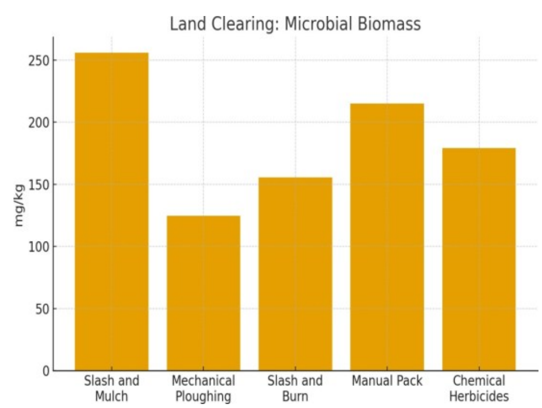


Figure 3: Land Clearing: Residual effect on soil potassium (K).

Figure 4: Land Clearing: Residual effect on microbial biomass

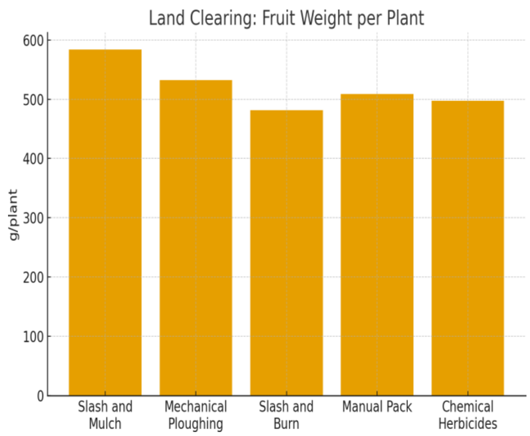


Figure 5: Land Clearing: Residual Effect on Fruit weight

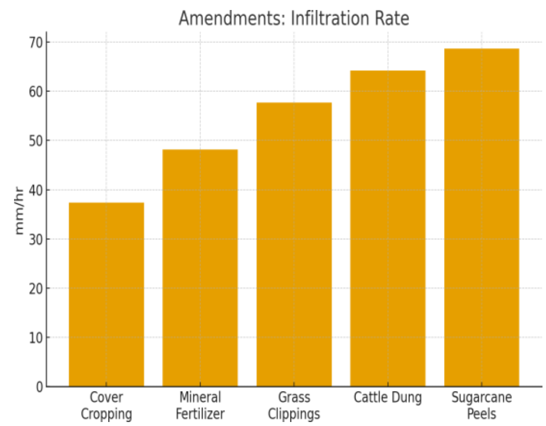


Figure 6: Soil Amendments: Residual Effects on Infiltration rate

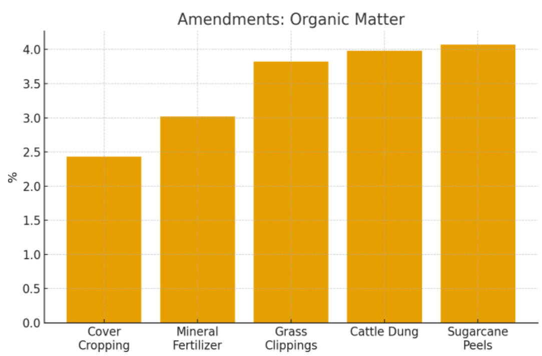


Figure 7: Soil Amendments: Residual effect on soil organic matter.

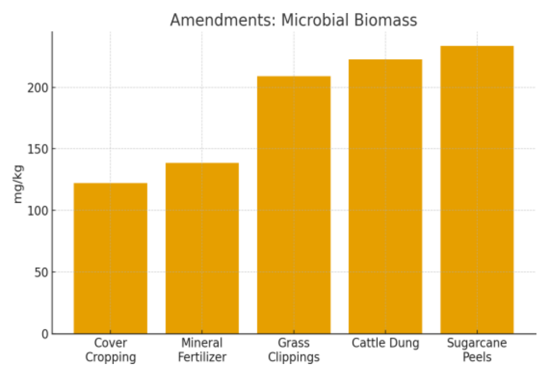


Figure 8: Soil Amendments: Residual effect on microbial biomass

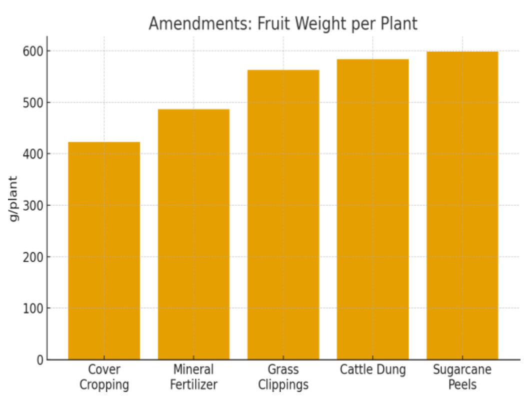


Figure 9: Soil Amendment: Residual effects on Tomato weight

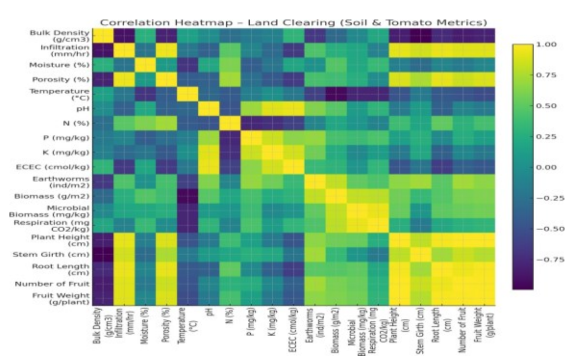


Figure 10: Correlation heatmap: Land clearing treatments fruit (soil vs. tomato metrics).

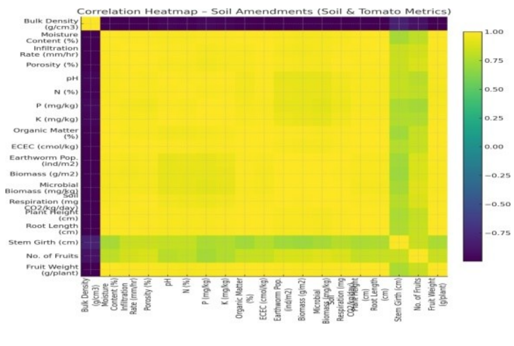


Figure 11: Correlation heatmap: Soil amendments (soil vs. tomato metrics).

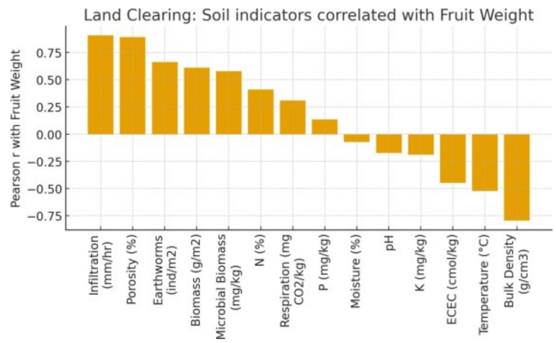


Figure 12: Land Clearing: Soil Indicators Correlated with fruit weight

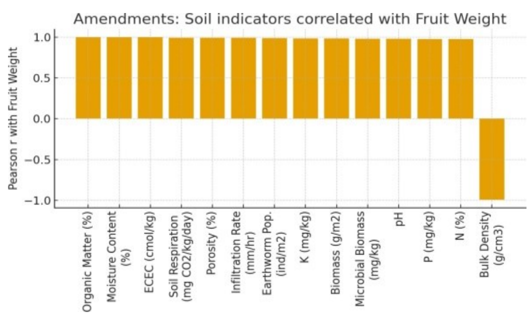


Figure 13: Amendments: Correlation of soil indicators with tomato fruit weight (soil amendments).

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