

Comparative Analysis of Volatile Organic Compound (Voc) Emission Levels Across Different Tillage Operations and Tractor Speeds in Agricultural Practices

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DOI: <https://doi.org/10.51583/IJLTEMAS.2025.140500097>

Received: 09 June 2025; Accepted: 13 June 2025; Published: 21 June 2025

Abstract: This study investigates the emission levels of Volatile Organic Compounds (VOCs) across different tillage operations and tractor speeds in agricultural practices. A field experiment was conducted on a 14.4-hectare farmland using four tractor models (MF new, MF old, NH new, NH old) at three different speeds (15 km/h, 20 km/h, and 24 km/h). The tillage operations included 1st plough, 2nd plough, harrowing, and ridging, with a total of 432 experimental runs. VOC emissions were monitored using a Multireal Pro Handheld Gas Analyzer. The results indicate that the highest VOC emissions occurred at 20 km/h, while at 24 km/h, emissions remained relatively stable across all tillage operations. Among the tillage operations, ridging and 1st ploughing exhibited the highest VOC emissions, while harrowing consistently produced the lowest. These findings emphasize the need for speed regulation and optimized tillage operations to mitigate environmental impact. Future research should explore sustainable tillage practices and emission control technologies to promote environmentally friendly farming.

Keywords: VOC emissions, tillage operations, tractor speed, sustainable agriculture, emission control

I. Introduction

Volatile Organic Compounds (VOCs) are critical contributors to air pollution, playing a key role in the formation of ground-level ozone and secondary organic aerosols (Atkinson, 2000). Agriculture, particularly through the use of tractors and other machinery, has been identified as a significant source of VOC emissions. Tillage operations, a fundamental component of soil preparation, involve varying tractor speeds and techniques, which directly influence the quantity and composition of emissions (Bavilnezhad et al. 2024; Bankole et al 2022).

Volatile organic compounds (VOCs) are a broad group of carbon-based substances characterized by a vapor pressure of ≥ 0.01 kPa at 20 °C, or by having similar volatility under relevant environmental conditions (Riikka et al 2025; Yu et al 2015). Although VOCs are often associated with pollution from tillage operations, industrial areas, landfills, and urban centers, they can also originate from natural sources and biological or (thermo) chemical processes (Riikka et al 2025; Indelicato et al 2017; Lemfack et al 2018). These sources include forests, soils, wetlands, volcanoes, gas seeps, and hydrothermal vents. Additionally, more than 600 bacterial species and 300 fungal species are known to produce VOCs (Riikka et al 2025; European Union 2023). These microbial VOCs encompass a range of chemical groups such as alkenes, alcohols, ketones, benzenoids, pyrazines, sulfides, and terpenes. In marine settings and shallow subsurface environments, microbial activity linked to VOC production is believed to play a significant role in biogeochemical cycles and in the release of these compounds into the surrounding environment (Zhuang et al 2019; Riikka et al 2025).

Tractor operations release VOCs primarily through fuel combustion, with emission levels influenced by factors such as tractor age, engine efficiency, and operational speed (Kutzbach et al., 2016). Hamid in his work observed different tillage operations, such as ploughing, harrowing, and ridging, demand varying power outputs and speed adjustments, resulting in differing VOC emission profiles. Despite the significance of these emissions, limited studies have explored the comparative impact of tillage operations and tractor speeds on VOC levels, particularly in developing countries where older tractors are prevalent (Teimouri et al. 2020).

This study aims to bridge this gap by conducting a comparative analysis of VOC emission levels across different tillage operations and tractor speeds. The findings will provide actionable insights into sustainable agricultural practices, offering guidance on minimizing emissions while maintaining operational efficiency.

II. Methodology of The Research

Experimental Area

The study was conducted in Lagos State University of Science and Technology (Formerly Lagos State Polytechnic) Ikorodu, west central state of Nigeria under the western vegetation in sandy-loamy soil. The current study area falls within geographical location 16°37'0" North, 3°37'0" east on the western part of Nigeria. 14.4 hectares of land was used for this study.

The Tools and Equipment Required for the Study

The tools and equipment required for the study are measuring tape, ranging pole, tractors, (new Holland, old and new), Massey Fergusson (old and new), 2 Hand held gas analyser (Multireal Pro), Disc plough, Disc harrow, Ridger, soil thermometer, soil core sample, rope, nylon bags, ruler, trowel, pegs, ranging pole.

Rating of the Tractors

The four tractors employed for the field study were rated based on the model and the usage hour of the tractors. The two models of tractors used were New Holland and Massey Fergusson. The usage hours of the tractors was used for the classification. Below 5000hrs of operations are NEW and above 5000hrs are OLD.

Experimental Variables

The following variables were combined to achieve accurate experimental results. The variables are Tractor age, Tractor model, Tillage speed (tractor speed) and Tillage depth. These variables were carefully combined for the different runs of the tractor.

Experimental Procedure

This field experiment was conducted on a carefully measured 400 meters by 360 meters mapped 14.4 hectares of land and later divided into 50 by 10 meters per each experimental plot as shown in figure. 1.

Table 1: Farm tractors specification used for the study

Specification	Massey Fergusson	Massey Fergusson	New Holland	New Holland
Model	MF435	MF435	TT55	TT55
Power rating	60-70hp	60-70hp	60-70hp	60-70hp
Types of engine	4 cylinder	4 cylinder	4 cylinder	4 cylinder
Types of fuel	Diesel	Diesel	Diesel	Diesel
Rated engine (rpm)	2500	2500	2500	2500
Tank capacity (L/h)	74	74	70	70
Front tyre size	7.50-16	7.50-16	7.50-16	7.50-16
Rear tyre size	14.9-30	14.9-30	14.9-30	14.9-30
Hours of usage	below 5000hrs	above 5000hrs	below 5000hrs	above 5000hrs

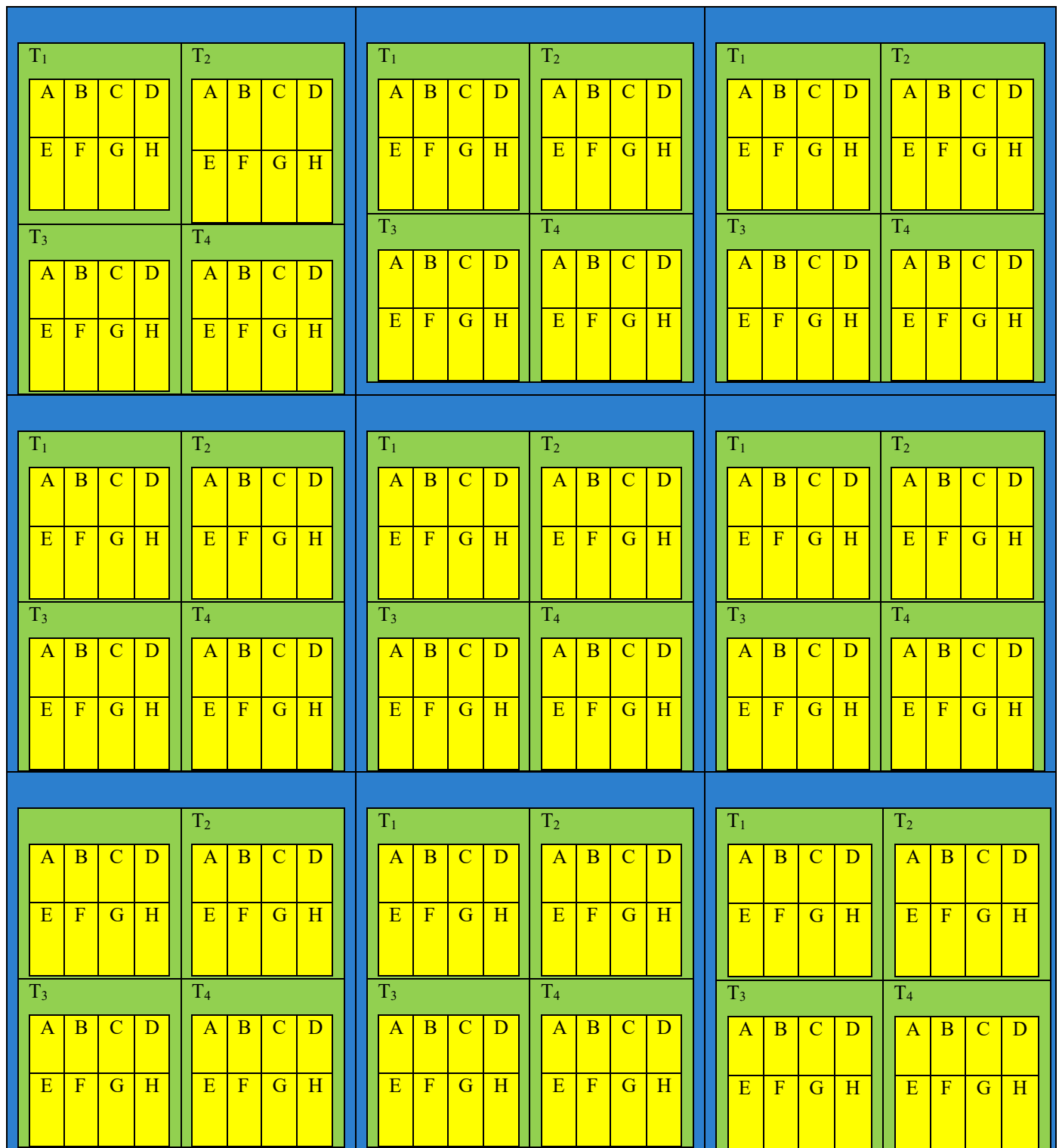
III. Results and Discussion

Results

From the results obtained, it was observed that various factors affected the emission of volatile organic compounds. These factors are the form of tillage operation, type of tractor, depth of cut and speed of operating the tractor. The results for volatile organic compounds emission before, during and after the tillage operation while operating the tractor at various speeds.

Table 2: Effect of tillage and speed of operation on Volatile organic compound emission

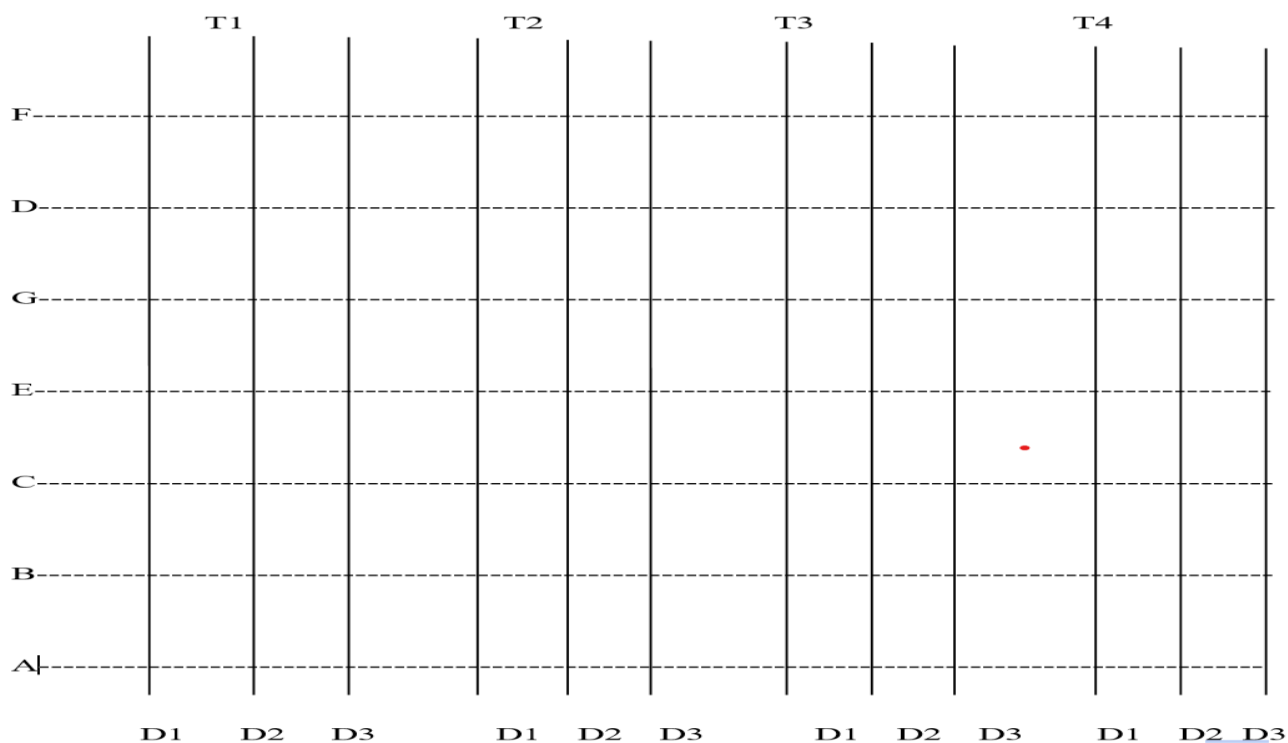
	Speed 1	Speed 2	Speed 3
1 st plough	13.07	20.59	11.78
2 nd plough	12.03	18.27	10.95
Harrowing	9.22	16.65	11.47
Ridging	13.47	21.21	12.14



A=1st plough only B=1st plough+2nd plough only C=1st plough 2nd plough and harrow only D=1st plough harrow only E=1st plough 2nd plough harrow ridge only F=1st plough harrow and ridge only G=Manual ridge only monitor H=1st plough 2nd plough and ridge only

Tractor Type:
T₁ = New Holland (New) T₂ = New Holland (Old)
T₃ = MF435 (New) T₄ = MF435 (Old)

Figure 1: Field experimental layout



T₁ = Mc Fergusson, New, T₂ = Mc Fergusson Old, T₃ = New Holland Old, T₄ = New Holland New, D₁ = depth of operation at 10cm, D₂ = depth of operation at 15cm, D₃ = depth of operation at 20cm, A-G = Experimental space

Figure 2: Tractor Allocation to Field Operation Site

Tillage Operation Procedure and Data Collection

The field operation involved measuring 14.4 hectares using a ranging pole, measuring tape, pegs, and rope. Four tractor types were used, each performing tillage operations (1st plough, 2nd plough, harrowing, and ridging) at depths of 10, 15, and 20 cm and speeds of 15, 20, and 24 km/h. A total of 432 runs were conducted, with speed monitored using the tractor's speedometer and depth measured with a steel tape. The Multireal Pro Hand Held Gas Analyzer recorded gas emissions before, during, and after tillage operations. Soil samples were collected after all tillage processes for further analysis

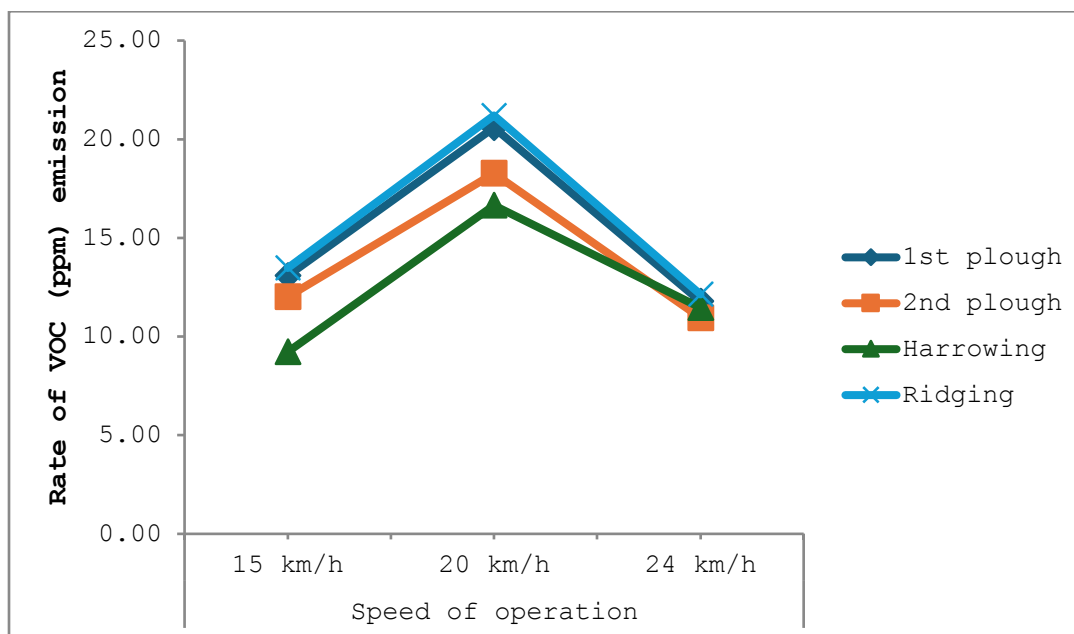


Figure 2: Effect of tillage and speed of operation on volatile organic compound emission

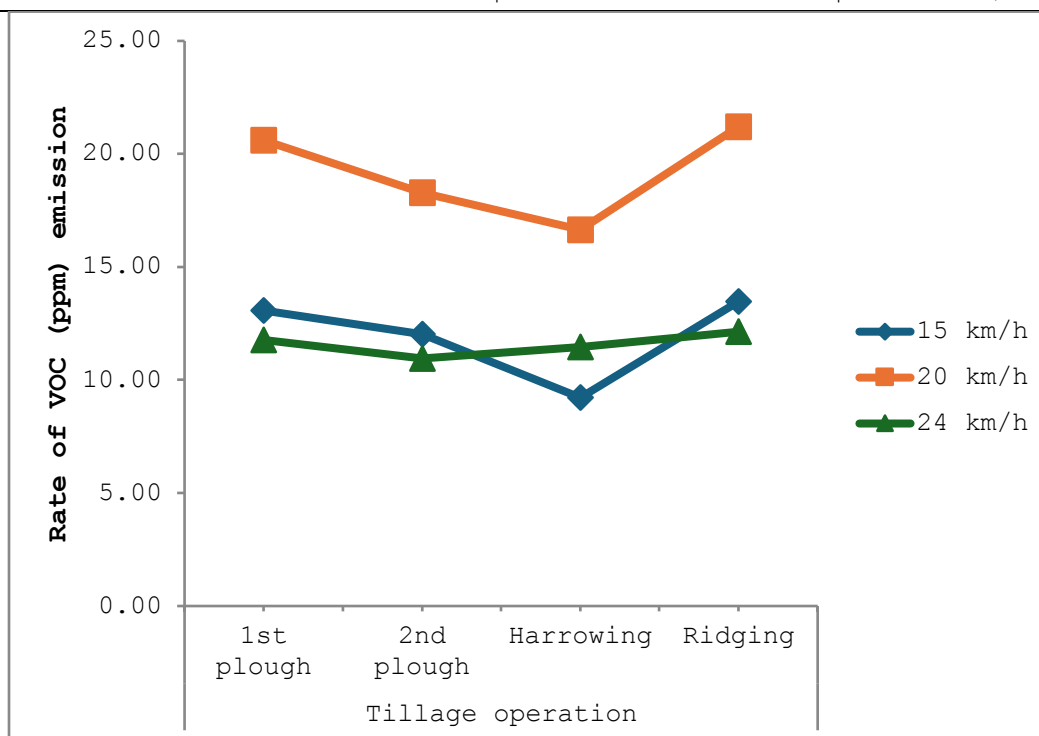


Figure 3: Effect of tillage and speed of operation on volatile organic compound emission

IV. Discussion

Effect of tillage and speed of operation on volatile organic compounds (VOC) gas emission.

From figure 2, the least value of VOC was recorded during harrowing operation at speed of 15km/hr with a value of 9.22. The higher values were recorded for second ploughing operation at all speeds of operation, with the highest value of 21.21 recorded for ridging operation at speed of 20km/hr. Maximum emissions of VOC was recorded at tractor speed 20km/hr. Figure 3, when running at a very high tractor speed 24km/hr the rate of emission of VOC is slightly constant across the four tillage operations. During intermediate speed of 20km/hr and low speed of 15km/hr figure 2, VOC emission rate is high during ridging. Figure 3, when the tractor runs at the highest and lowest speed, VOC emission rate slightly varies between 1st plough, 2nd plough and ridging. Figure 3 from table 2 there exist no significant differences between the amount of VOC generated under the following combination of tillage operation types and speeds of operation: first ploughing at 15km/hr and ridging at 15km/hr; first and second ploughing at 15km/hr and ridging at 24km/hr; first ploughing at 20km/hr and ridging at 20km/hr; first ploughing at 24km/hr second ploughing at 15km/hr harrowing at 24km/hr and ridging at 24km/hr; first ploughing at 24km/hr second ploughing at 15km/hr and 24km/hr and harrowing 24km/hr. However, there are significant differences between the amount of VOC generated during second ploughing at 20km/hr and harrowing at both 15km/hr. and 20km/hr. table 2 there exist no significant differences between the amount of VOC generated under the following combination of tillage operation types and speeds of operation: first ploughing at 15km/hr and ridging at 15km/hr; first and second ploughing at 15km/hr and ridging at 24km/hr; first ploughing at 20km/hr and ridging at 20km/hr.

Summary of VOC Emission Analysis in Tillage Operations

The analysis of VOC (Volatile Organic Compounds) emissions during tillage operations revealed that emissions varied based on tractor speed and tillage operation type. At an intermediate speed of 20 km/h, VOC emissions were highest across all tillage operations, while at the highest speed of 24 km/h, emission rates remained relatively constant. Among the tillage operations, ridging and 1st ploughing showed similar VOC emission patterns, particularly at 20 km/h. Harrowing consistently recorded the lowest VOC emissions.

V. Conclusion

The comparative analysis of VOC emissions across different tillage operations and tractor speeds reveals that tractor speed plays a crucial role in emission levels. The highest VOC emissions were recorded at an intermediate speed of 20 km/h, indicating that moderate speeds contribute more to emissions than extreme high (24 km/h) or low (15 km/h) speeds. At the highest speed, VOC emissions remained relatively constant across all tillage operations, suggesting that rapid movement may limit prolonged interaction between soil and tractor emissions. Among the tillage operations, ridging and 1st ploughing exhibited similar VOC emission trends, while harrowing consistently had the lowest emission levels. This suggests that soil disturbance intensity affects VOC release, with more disruptive operations producing higher emissions.

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