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Effects of Different Concentrations of Agricultural Pesticides on Rhizosphere Microbial Populations of Maize (*Zea mays*)

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ABSTRACT

Pesticides protect crops, but may also affect non-target microorganisms important to soil functioning. This study evaluated Lambdashi (lambda-cyhalothrin), Temifos (chlorpyrifos) and Cyperforce (cypermethrin) at 0.07%, 0.35% and 0.70% in the rhizosphere of maize (*Zea mays*) grown in soil from the Rivers State University Demonstration Farm, Port Harcourt, Nigeria. In a controlled pot experiment, total heterotrophic bacteria (THB), coliforms, heterotrophic fungi and phosphate-solubilising bacteria (PSB) were assessed by culture-based methods at baseline and every two weeks for eight weeks. THB, coliform and fungal counts generally decreased with increasing concentration and exposure time, while untreated controls were comparatively more stable. At 0.70%, THB declined from 3.1×10^7 to 3.7×10^4 CFU/g with Lambdashi, from 2.35×10^7 to 2.16×10^4 CFU/g with Temifos, and from 5.9×10^7 to 1.35×10^4 CFU/g with Cyperforce. Coliforms under 0.70% Lambdashi decreased from 1.7×10^5 to 1.81×10^2 CFU/g. Fungal counts at 0.70% fell from 1.21×10^4 to 1.02×10^2 CFU/g with Lambdashi, from 2.5×10^4 to 1.02×10^3 CFU/g with Temifos, and from 6.9×10^4 to 1.32×10^3 CFU/g with Cyperforce. These reductions suggest marked suppression of culturable microbial groups and potential effects on decomposition, nutrient cycling and rhizosphere biological functioning. PSB counts in treated soils were reported only at baseline, so their response over time could not be determined; by contrast, PSB in untreated maize soil increased from 2.9×10^3 to 4.3×10^3 CFU/g by week 8. Given the marked reductions at 0.70% and subsequent non-recovery of PSB, this concentration should not be recommended for routine field use until replicated field trials establish an acceptable dose-response relationship. Pesticide use should remain within approved product-label rates, and post-treatment monitoring should specifically assess PSBs recovery alongside THB, coliform and fungal counts.

Keywords: Agricultural Pesticides, Maize Rhizosphere, Microbial Populations, Lambdashi, Temifos, Cyberforce.

Introduction

Pesticides are widely used in agricultural production to suppress insects, weeds, fungal pathogens and other pests that can reduce crop yield and quality. By limiting crop damage and post-harvest losses, these chemicals can support food production and farm productivity. Pesticides encompass diverse chemical products, including insecticides, herbicides and fungicides, which differ in their targets and modes of action (Ojo, 2016). However, the benefits of pest control must be considered alongside the potential for non-target exposure. Concerns have been raised in Nigeria about pesticide handling, inappropriate use and pesticide residues in food and the environment (Amusat et al., 2023; Abubakar et al., 2024).

These concerns make it important to examine not only pesticide efficacy against target pests, but also their possible effects on soil organisms that support agricultural ecosystems.

After application, pesticides may remain in soil, undergo chemical or biological transformation, bind to soil particles, or move through runoff and leaching into connected environmental compartments. Their persistence and movement depend on the properties of the active ingredient and formulation as well as environmental conditions. Some microorganisms can transform or degrade pesticide compounds, but exposure can also change the abundance and composition of native microbial communities (Wanguyun & Geraldi, 2019; Thiour-Mauprivez et al., 2019).

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Soil microorganisms are central to soil biological functioning. They contribute to the decomposition and transformation of organic matter, nutrient cycling and the maintenance of conditions that support plant growth. The rhizosphere—the soil directly influenced by plant roots—is particularly important because root-associated resources can support active microbial populations, while agricultural inputs may expose these populations to changing chemical conditions.

Changes in microbial abundance or activity in this zone may therefore provide useful evidence of how pesticide treatments influence the biological environment surrounding growing crops. Phosphate-solubilising bacteria (PSB) are of particular interest because their activity can increase the availability of phosphorus from poorly soluble forms; pesticide effects on such organisms may consequently be relevant to soil fertility and plant nutrition (Shahid et al., 2021).

The effects of pesticides on soil microbiota are not necessarily uniform. They may vary with the chemical class and mode of action of the pesticide, the concentration applied, the duration and frequency of exposure, and the characteristics of the soil and resident microbial community. Depending on these factors, pesticide exposure may suppress some microbial populations, alter community composition, or favour organisms capable of tolerating or transforming particular compounds.

Obire and Eli (2014) examined the effects of different pesticide concentrations on soil bacteria and fungi, while Qardash et al. (2019) reported changes in soil bacterial populations following exposure to several pesticides. Sebiomo and Banjo (2021) also found that synthetic insecticides affected soil microbial populations and microbial activities. These findings support the need to evaluate responses at more than one concentration and over time, rather than inferring environmental effects from a single exposure level.

Although previous studies by Imfeld & Vuilleumier (2012) have examined pesticide effects on soil microorganisms and microbial communities, their findings arise from different pesticides, soil types, exposure conditions and measurement approaches. These differences limit direct extrapolation to the combined effects of the products and concentration range assessed here.

A crop-specific evaluation of microbial populations under repeated pesticide application can help clarify whether observed responses vary by pesticide, concentration, crop and sampling period. Such evidence is relevant to the interpretation of soil microbial indicators and to decisions about pesticide use in agricultural systems.

The present study focuses on three pesticide products identified in the source materials as Lambdashi, Temifos and Cyperforce, associated respectively with lambda-cyhalothrin, chlorpyrifos and cypermethrin. These active ingredients represent different insecticide chemistries, so their effects on the soil microbial community should not be assumed to be identical.

Evaluating them at graded concentrations under a controlled crop-growing experiment permits comparison of microbial population trends while limiting some of the variation encountered in field surveys. Maize (*Zea mays*) was selected as the crop of interest, with soil obtained from the Rivers State University Demonstration Farm in Port Harcourt, Nigeria.

Accordingly, this study evaluated the effects of different concentrations of Lambdashi, Temifos and Cyperforce on culturable microbial populations in the rhizospheres of maize grown in soil from the Rivers State University Demonstration Farm.

Materials and Methods

Study area and soil collection

The study was conducted, using soil collected from the Rivers State University Demonstration Farm in Port Harcourt, Rivers State, Nigeria. The soil samples were collected from a depth of 0–15 cm for use in a controlled pot experiment. The soil was used to establish crop setups for maize (*Zea mays*).

Experimental design and pesticide application

Following the modified methods of Obire and Eli (2014),) Nrior *et al.* (2022) and Gangola *et al.* (2023), 10 kg of pristine soil was measured into each of 20 experimental bags, comprising 10 setups each for maize. Four viable seedlings of maize crop were planted per setup.

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Following the methods of Cycon *et al.* (2010), 25% emulsion pesticide formulations of Temifos, Lambdashi and Cyperforce were applied at concentrations of 7, 35 and 70 mg/kg to separate setups after two weeks of plant growth.

The pesticides were reapplied fortnightly for three months, while the plants were watered daily.

One setup per crop without pesticide application served as the control. Soil microbials populations and plant growth were assessed fortnightly throughout the experimental period until maturity and fruit production. The experimental setups to determine the effect of the Pesticides (Lambdashi, Temifos and Cyberforce) on the Rhizosphere soil samples are as presented in Table 1.

Table 1: Experimental setups to determine the effect of the Pesticides on the Rhizosphere soil samples

Concentration of Pesticide	**Experimental setups to determine the effect of the Pesticides on Maize (*Zea mays*) rhizosphere bacteria**		
	Lambda	**Temifos**	**Cyberforce**
7 mg/kg	Soil + Maize seedling + Lambda	Soil + Maize seedling + temifos	Soil + Maize seedling + cyberforce
35 mg/kg	Soil + Maize seedling + Lambda	Soil + Maize seedling + temifos	Soil + Maize seedling + cyberforce
70 mg/kg	Soil + Maize seedling + Lambda	Soil + Maize seedling + temifos	Soil + Maize seedling + cyberforce
Control	Soil + Maize seedling without any Pesticide		

Each pesticide was applied at concentrations reported as 0.07%, 0.35% and 0.70%, at two-week intervals over an eight-week period. Untreated crop setups served as controls. Microbial populations were monitored at the beginning of the experiment and at weeks 2, 4, 6 and 8.

Enumeration of microbial populations

Microbial populations were enumerated using culture-based methods, and counts were expressed as colony-forming units per gram of soil (CFU/g). The microbial groups were total heterotrophic bacteria, total coliforms, heterotrophic fungi and phosphate-solubilizing bacteria.

A homogenate of the soil samples from each of the experimental setups was inoculated into 90ml of normal saline and homogenized for 30 seconds aseptically.

Ten-fold serial dilution was carried out by transferring 1ml from the residue homogenate aseptically using a sterile pipette to the first test tube containing 9ml normal saline (diluent), the same procedure was repeated to dilution 10^{-7}.

After dilution, aliquot (0.1ml) of the diluted samples was cultured on different media (Nutrient agar (NA), Potato Dextrose agar (PDA) and Pikovskaya agar) using sterile hockey stick.

The cultured plates were incubated aerobically at 35°C for 24hours (for NA) and 2-5 days (for Pikovskaya agar) and 28-30°C for 48-72 hours (for PDA). After incubation, the Total Heterotrophic count of the bacteria (THBC), Total Fungal Count (TFC), and total count of phosphate-solubilizing bacteria (on Pikiovskaya agar) was determined by counting the colonial growth on the cultured plates, and the CFU/g (colony forming unit) was calculated (Bajestani et al. (2025); Aina & Olaleye (2023).

Statistical analysis

Data derived were analyzed using Statistical Package for Social Sciences (SPSS) version 20.0. Three replicates were used for each treatment at each time point and three-way analysis of variance (ANOVA) was performed; followed by least significant difference (LSD) comparisons at $p < 0.05$, was used to assess microbial characteristics. Means, variability, effect sizes and exact P-values were determined.

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Results

Total heterotrophic bacterial counts (population) declined in the pesticide-treated maize rhizospheres over the eight-week monitoring period. The total heterotrophic count of the rhizosphere of the maize applied with Lambda during the experimental period of 8 weeks is shown in Figure 1. There was a progressive reduction of the count of THB in the rhizosphere of the planted maize in relation to the concentration of the applied agrochemical during the 8 weeks of the study period. At 0.07% 0f lambda, the THB count reduced from 4.3 $\times 10^7$ to 5.7 $\times 10^5$ CFU/g, 0.3% concentration resulted in reduction from 3.9 $\times 10^7$ to 8.6 $\times 10^4$ while concentration of 0.70% resulted in a reduction of heterotrophic bacteria from 3.1 $\times 10^7$ to 3.7 $\times 10^4$.

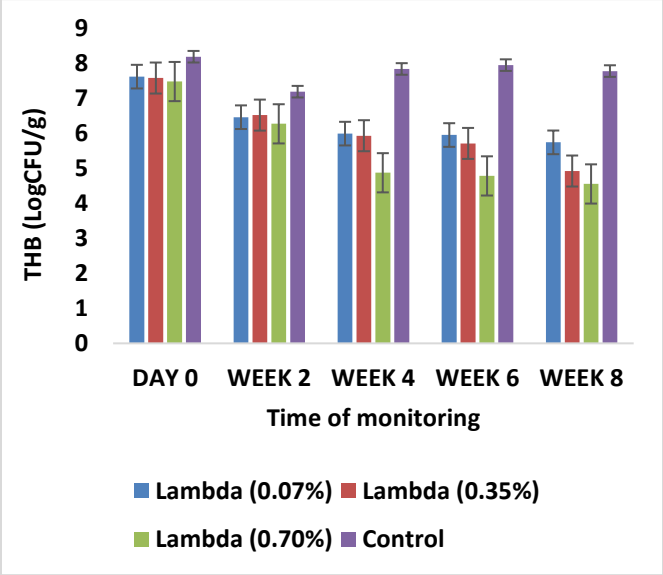


Fig. 1: Total Heterotrophic bacterial (THB) count of the Rhizosphere of maize with lambda

The total heterotrophic count of the rhizosphere of the maize applied with Temifos during the experimental period of 8 weeks is shown in Figure 2. The application of Temifos to the maize at a concentration of 0.07% resulted in a reduction of heterotrophic bacteria population of 6.9 $\times 10^7$ to 8.9 $\times 10^5$CFU/g, at 0.35% of Temifos, THB population of 3.2 $\times 10^7$ CFU/g recorded on day 0 reduced to 7.6 $\times 10^4$ CFU/g on week 8 while at concentration of 0.70%, population of 2.35 $\times 10^7$ recorded at the beginning of the study and reduced progressively to 2.16 $\times 10^4$ CFU/g.

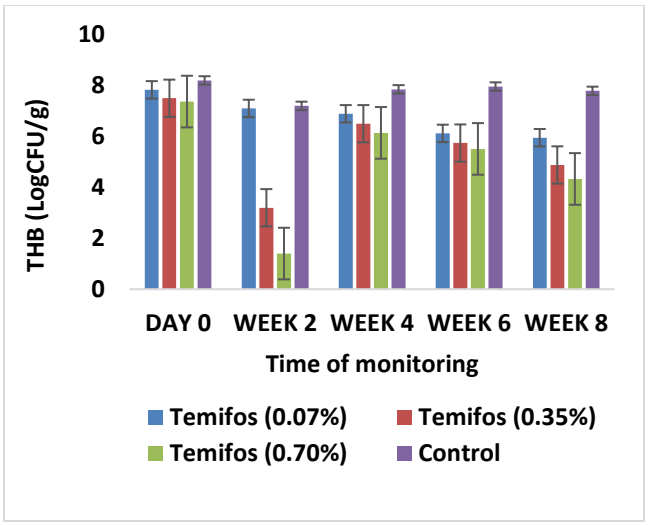


Fig. 2: Total Heterotrophic bacterial (THB) count of the Rhizosphere of maize with Temifos

The total heterotrophic count of the rhizosphere of the maize applied with cyberforce during the experimental period of 8 weeks is shown in Figure 3. For the application of cyberforce, recorded reductions were from 7.1×10^7 to 7.8×10^5 CFU/g, 6.1×10^7 to 6.8×10^4 CFU/g, and 5.9×10^7 to 1.35×10^4 CFU/g for concentrations of 0.07%, 0.35%, and 0.7%, respectively. The control setup containing the maize without application of pesticides (control setup) recorded total heterotrophic count of 6.5 $\times 10^7$ CFU/g, 8.2 $\times 10^7$ CFU/g, 7.2 $\times 10^7$ CFU/g, 9.3×10^7 CFU/g and 3.16 $\times 10^7$ CFU/g at week 0, 2, 4, 6, and 8 respectively.

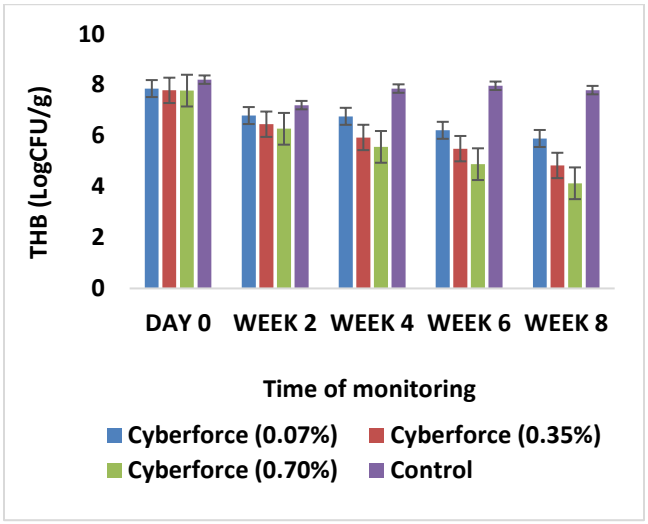


Fig. 3: Total Heterotrophic bacterial (THB) count of the Rhizosphere of maize with cyberforce

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Total coliform counts also decreased between the beginning and end of the study in the treated maize rhizospheres. In the application of Lambda to maize seedling recorded a reduction of total coliform from week 0 to week 8 from population the 3.2×10^5 to 1.4×10^4 CFU/g, 2.5×10^5 to 7.7×10^2 CFU/g, 1.7×10^5 to 1.81×10^2 CFU/g, 0.07, 0.35% and 0.7% respectively (Figure 4).

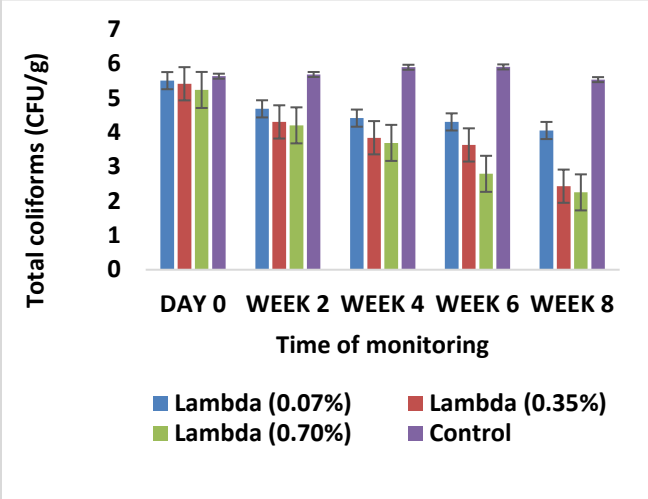


Fig. 4: Count of coliform of rhizosphere of maize with Lambda

For the application of Temifos to maize plant, recorded a reduction of coliform population of 2.8×10^5 to 9.3×10^3 CFU/g, 2.3×10^5 to 7.4×10^3 CFU/g, 2.0×10^5 to 6.3×10^2 CFU/g for 0.07%,0.35% and 0.70%, respectively (Figure 5).

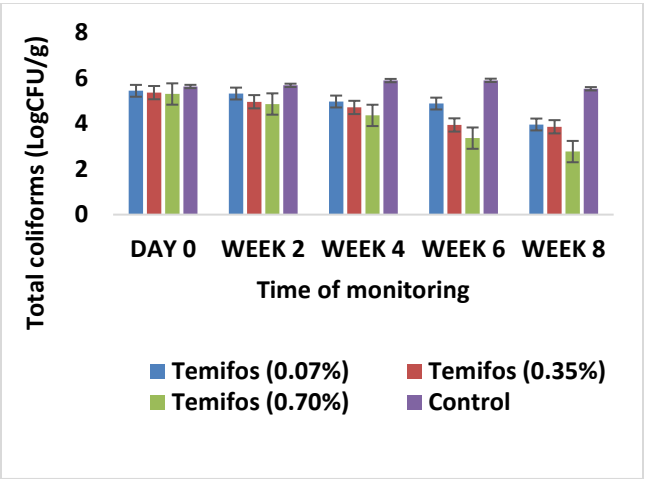


Fig. 5: Count of coliform of rhizosphere of maize with Temifos

While at the application of cyberforce to maize seedling/plant resulted in a reduction of 3.5×10^5 to 3.8×10^3 CFU/g, 2.17×10^5 to 7.3×10^2 CFU/g, and 1.11×10^5 to 3.1×10^2 CFU/g for 0.07%, 0.35%, and 0.7% concentration, respectively (Figure 6).

The control setup containing of the maize plant without application of pesticides (control setup) recorded total coliform count of 4.3 $\times10^5$ CFU/g, 4.8 $\times10^5$ CFU/g, 7.8 $\times10^5$ CFU/g, 8.4×10^5 CFU/g and 3.6 $\times10^5$ CFU/g at week 0, 2, 4, 6, and 8 respectively.

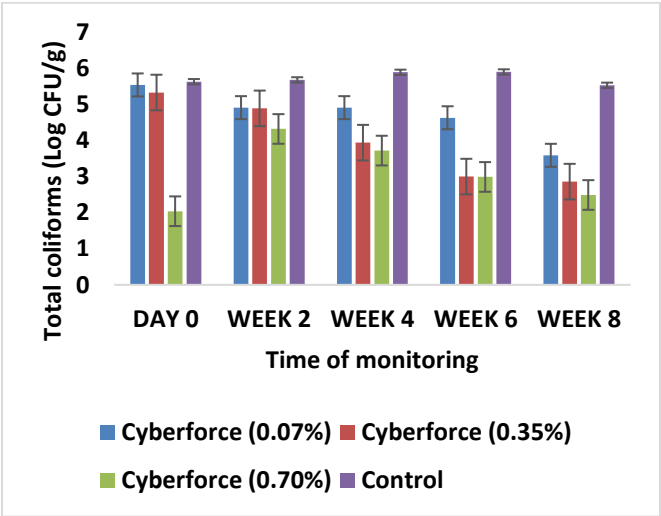


Fig. 6: Count of coliform of rhizosphere of maize with Cyberforce

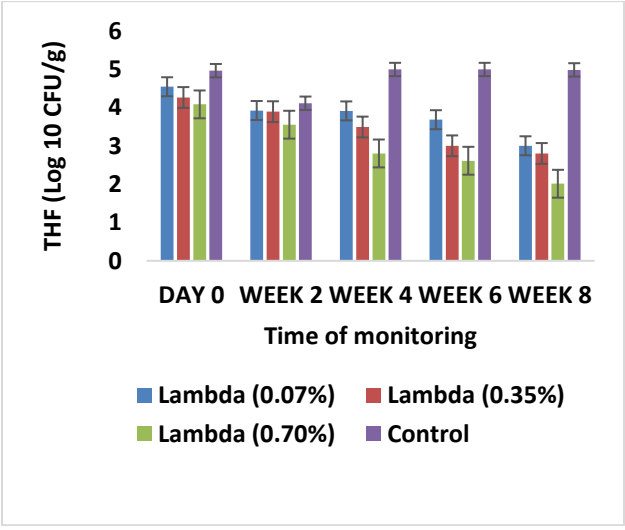


Fig. 7: Total Heterotrophic fungal (THF) count of maize rhizosphere with lambda

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Application of Lambda to maize rhizosphere resulted in the reduction in the count of Total Heterotrophic fungi from 3.5×10^4 CFU/g to 1.0×10^3 CFU/g, 1.82×10^4 to 6.4×10^2 and 1.21×10^4 to 1.02×10^2 CFU/g for 0.07%, 0.35% and 0.70% respectively of Lambda concentration (Figure 7).

Reduction of heterotrophic fungal count of 9.0×10^4 to 9.62×10^3 CFU/g, 3.8×10^4 to 2.8×10^3 CFU/g and 2.5×10^4 to 1.02×10^3 CFU/g for 0.07%, 0.35% and 0.7% concentration respectively were recorded in the application of Temifos to maize plants (Figure 8).

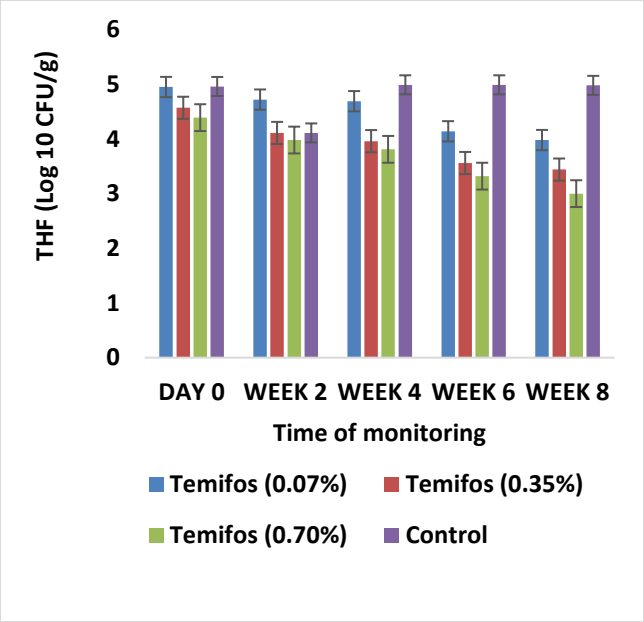


Fig. 8: Total Heterotrophic fungal (THF) count of maize rhizosphere with Temifos

Additionally, there was reduction of population in the count of heterotrophic fungi where cyberforce was applied to maize plant.

It resulted in decline in population of 9.1×10^4 to 9.4×10^3, 8.4×10^4 to 3.3×10^3 and 6.9×10^4 to 1.32×10^3 CFU/g respectively for 0.07%, 0.35% and 0.7% concentration (Figure 9).

The control setup containing the maize plant without application of pesticides (control setup) recorded heterotrophic fungal count of 9.3×10^4 CFU/g, 4.9×10^4 CFU/g, 8.3×10^4 CFU/g, 9.8×10^4 CFU/g and 9.7×10^5 CFU/g at week 0, 2, 4, 6, and 8 respectively.

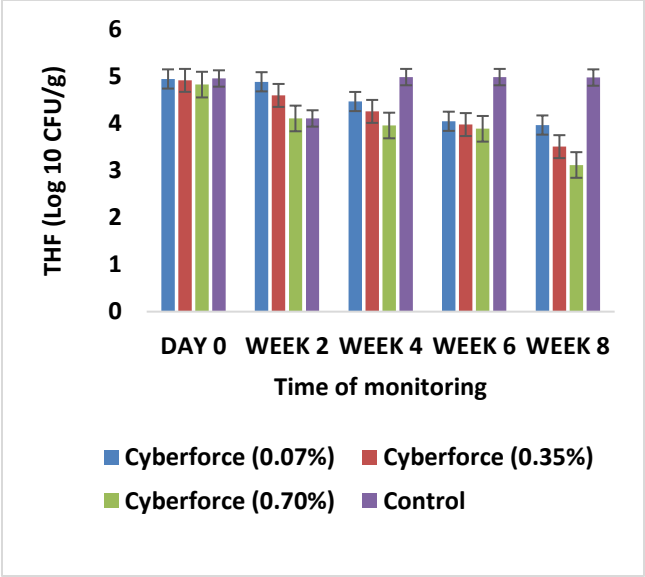


Fig. 9: Total Heterotrophic fungal (THF) count of maize rhizosphere with cyperforce

The counts of phosphate solubilizing bacteria were not recorded weeks after the application of Lambda, Temifos and cyberforce pesticides to the maize plant at different concentration. However, on the first day of the application, the count of 2.35×10^3 CFU/g, 1.4×10^3 CFU/g and 1.3×10^3 CFU/g of concentration of 0.07%, 0.35% and 0.70% respectively were recorded from the rhizosphere of maize applied with Lambda (Figure 10).

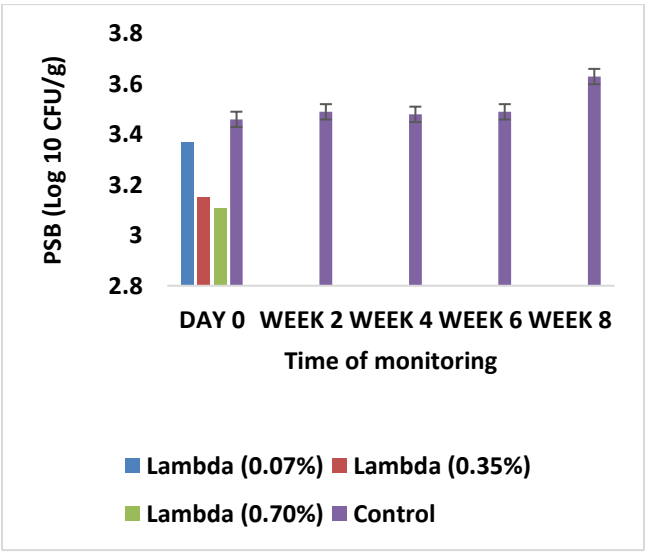


Fig. 10: Count of Phosphate Solubilizing Bacteria (PSB) of maize rhizosphere applied with Lambda

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Additionally, the count of 2.30×10^3 CFU/g, 2.78×10^3 CFU/g and 2.57×10^3 CFU/g of concentration of 0.07%, 0.35% and 0.70% respectively were recorded from the rhizosphere of maize applied with Temifos (Figure 11).

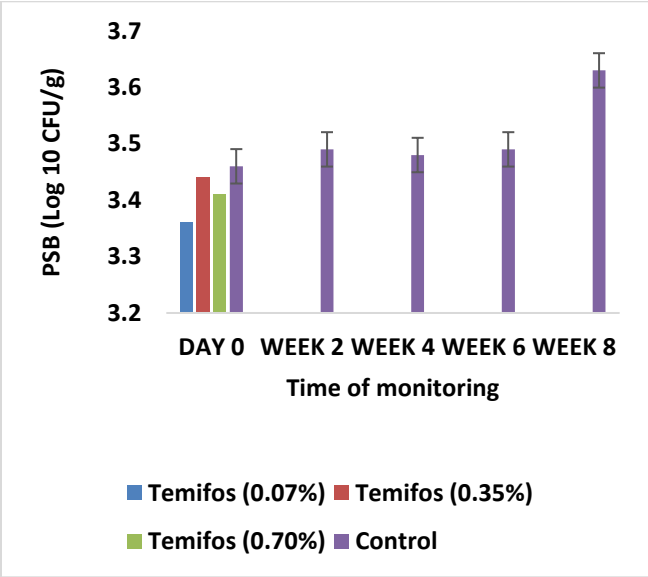


Fig. 11: Total count of Phosphate Solubilizing Bacteria (PSB) of maize rhizosphere applied with Temifos

The count of 4.30×10^3 CFU/g, 3.2×10^3 CFU/g and 2.8×10^3 CFU/g of concentration of 0.07%, 0.35% and 0.70% respectively were recorded from the rhizosphere of maize applied with cyberforce (Figure 12).

For the control set up, the count of phosphate solubilizing bacteria of 2.9×10^3 CFU/g, 3.1×10^3 CFU/g, 3.0×10^3 CFU/g, 3.1×10^3 CFU/g and 4.3×10^3 CFU/g on day 0, week 2, week 4, week 6 and week 8 respectively were recorded from the rhizosphere of maize plant without the application of any pesticide.

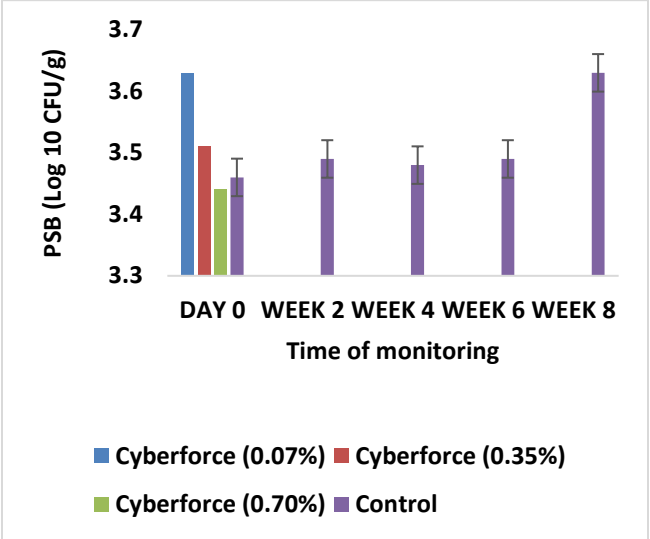


Fig. 12: Total count of Phosphate Solubilizing Bacteria (PSB) of maize rhizosphere applied with cyperforce

Discussion

The application of Lambda (lambda-cyhalothrin), Temifos (chlorpyrifos) and Cyperforce (cypermethrin) generally reduced total heterotrophic bacterial (THB), total heterotrophic fungal (THF) and total coliform populations in the rhizospheres of maize. The reductions were generally more pronounced at higher pesticide concentrations and with prolonged exposure, whereas untreated controls maintained comparatively stable microbial populations. These findings agree with Qardash et al. (2019), AL Sadek and Al Hammadi (2015), and Nrior et al. (2022), who associated pesticide exposure with concentration-dependent microbial inhibition, potentially involving enzyme inactivation and impaired microbial recovery. Similarly, Sebiomo and Banjo (2020) and Momoh et al. (2020) reported reductions in soil bacterial populations following pesticide application.

Shanthi et al. (2022) also observed bacterial inhibition at higher pesticide concentrations. However, pesticide effects may vary with the chemical compound, concentration and microbial group. Bawa et al. (2025) reported that dimethoate and lambda-cyhalothrin did not reduce the abundance of peanut-associated phosphate-solubilising bacteria, although they altered genetic diversity and the frequency of pqq genes. Similarly, Sodhozai et al. (2024) found that lambda-cyhalothrin stimulated the growth of *Pseudomonas aeruginosa* but inhibited *Bacillus subtilis*. These findings suggest that microbial responses to pesticides are species-dependent and may involve changes in community composition and genetic characteristics, even when overall abundance is not reduced. Total coliform populations followed a similar declining trend, particularly at higher pesticide concentrations. This agrees with Sebimo (2021), who reported coliform reduction following chlorpyrifos application.

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Fungal populations also declined following pesticide exposure, consistent with the findings of Momoh et al. (2020) and Sebimo (2021). The simultaneous reduction of bacterial and fungal populations suggests that the pesticides affected multiple groups of culturable soil microorganisms. This is ecologically important because soil fungi contribute to decomposition, carbon turnover, nutrient cycling and plant–soil interactions. Phosphate-solubilising bacteria (PSB) were not monitored throughout the experimental period in pesticide-treated plants; only initial counts were recorded, while control plants were monitored subsequently. Consequently, the effects of the pesticides on PSB populations over time could not be adequately established. Nevertheless, Shanid et al. (2021) reported concentration-dependent inhibition of phosphate-solubilising activity in *Enterobacter cloacae* following pesticide exposure, while Nrior et al. (2022) reported lambda-cyhalothrin toxicity to *Pantoea dispersa* in freshwater systems. These findings highlight the potential vulnerability of beneficial soil microorganisms to pesticide exposure, although further measurements are needed to confirm such effects under the conditions of the present study.

Conclusion

The study established that soil from the Rivers State University Demonstration Farm supported indigenous populations of heterotrophic bacteria, fungi, coliforms and phosphate-solubilising bacteria. Application of Lambda, Temifos and Cyperforce generally reduced bacterial, fungal and coliform populations in the crop rhizospheres, with stronger inhibitory effects associated with higher pesticide concentrations and prolonged exposure. These findings suggest that excessive or repeated pesticide application may adversely affect non-target soil microorganisms and potentially compromise soil biological functioning. Pesticides should therefore be applied according to verified product instructions and appropriate agricultural guidance, while soil microbial indicators should be monitored where repeated application occurs. Further replicated field studies incorporating pesticide-residue analysis, microbial-community characterisation and functional assays are recommended to clarify the long-term implications for pesticide degradation, nutrient cycling and plant nutrient availability.

References

Abubakar, M. G., Hamza, A. B., & Moriki, B. I. (2024). Assessment of pesticide residue in food commodities from North-Western Nigeria: Implications for food safety and public health. *International Journal of Science for Global Sustainability, 10*(4), 1–19.

Aina, O. R., & Olaleye, O. N. (2023). Impact of pesticides on microbial population in LASUSTECH agricultural field, Nigeria. Nigerian Journal of Microbiology, 37(1), 6459–6468.

AL Sadek, E., & Al Hammadi, M. (2015). Study the effect of insecticides commonly used locally on the bacteria of economic importance in the soil. *Assiut University Bulletin of Environmental Research, 18(1*), 29–42.

Amusat, A. I., Okewole, S. A., Rafiu, R. A., & Amusat, M. A. (2023). Overview of pesticides usage, misuse and its impact on environmental degradation in South-Western states and some part of Northern states in Nigeria. *Journal of Pesticides Science and Pest Control, 2*(1), 1–12.

Bajestani, M. S., Kiani, F., Ebrahimi, S., Malekzadeh, E., & Tatari, A. (2025). Effects of bentonite/sodium alginate/nanocellulose composites on soil properties and their biodegradability over time. Scientific Reports, 15, 10596.

Bawa, Y. M., Kalimullah, S., & Wagini, N. H. (2025). The effects of pesticide application on soil microbiota and weed dynamics in cowpea cropping systems. *UMYU Scientifica*, *4*(1), 150–159.

Cycon, M., Piotroska-Seget, Z. & Kozdroj, J. (2010). Microbial Characteristics of Sandy Soil Exposed to Diazinon Under Laboratory Conditions. *World Journal of Microbiology Biotechnology*, 26, 409-418.

Gangola, S., Joshi, S., Bhandari, G., Pant, G., Sharma, A., Perveen, K., Bukhari, N. A., & Rani, R. (2023). Exploring microbial diversity responses in agricultural fields: A comparative analysis under pesticide stress and non-stress conditions. *Frontiers in Microbiology, 14*, Article 1271129.

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Imfeld, G., & Vuilleumier, S. (2012). Measuring the effects of pesticides on bacterial communities in soil: A critical review. *European Journal of Soil Biology,* 49, 22–30.

Momoh, D., Eze, C. L., & Ogbonna, D. N. (2020). Impact of drifts resulting from pesticide application on soil microorganisms around waste receptacles in Port Harcourt City, Nigeria. *Biotechnology Journal International, 24(6),* 1–8.

Nrior, R. R., Douglas, S. I., & Igoni, Y. G. (2022). Toxicity of herbicide, paraquat dichloride and insecticide, lambda-cyhalothrin on phosphate solubilizing bacteria, *Pantoa dispersa* in aquatic ecosystems. *Microbiology Research Journal International, 32(4),* 13–21.

Obire, O., & Eli, J. O. (2014). Impact of various concentrations of some pesticides on soil bacteria and fungi. *Current Studies in Comparative Education, Science and Technology, 1*, 139–145.

Ojo, J. (2016). Pesticide use and health in Nigeria. *Ife Journal of Science, 18*(4), 981–991.

Qardash, A. A. F., Al-Helali, M. F., Thabet, A. A. M., & Ba'abad, M. A. (2019). Study on the effects of six pesticides on soil bacteria in laboratory. *Asian Journal of Crop, Soil Science and Plant Nutrition, 1(1),* 17–22.

Sebiomo, A. (2021). Microbial activities and physicochemical properties of pesticide treated soils and waters. *Natural and Applied Sciences Journal, 4(1),* 38–51.

Sebiomo, A., & Banjo, F. (2020). Abilities of indigenous microorganisms to utilise herbicides for growth and as carbon source in vitro. *Cumhuriyet Science Journal, 41(4),* 784–801.

Sebiomo, A., & Banjo, F. (2021). Effects of selected synthetic and biological insecticides on microbial population and microbial activities of soil samples. *Journal of the Turkish Chemical Society Section A: Chemistry, 8(1),* 229–238.

Shanid, M., Manoharadas, S., Altaf, M., & Alrefaei, A. F. (2021). Organochlorine pesticides negatively influenced the cellular growth, morphostructure, cell viability, and biofilm-formation and phosphate-solubilization activities of *Enterobacter cloacae* strain EAM 35. *ACS Omega, 6(8)*, 5548–5559.

Shanthi, T. R., Hatha, M., & Satyakeerthy, T. R. (2022). A study on the diversity of pesticide-resistant bacterial population from different agricultural fields of Manjoor. *Nature Environment and Pollution Technology, 21(3),* 1209–1216.

Sodhozai, A. R., Bibi, S., Rabia, M., Jadoon, M., Akhtar, H., & Ali, N. (2024). From growth inhibition to ultrastructural changes: Toxicological assessment of lambda cyhalothrin and fosetyl aluminium against *Bacillus subtilis* and *Pseudomonas aeruginosa. Environmental Research, 252*(Part 2), Article 118958.

Thiour-Mauprivez, C., Martin-Laurent, F., Calvayrac, C., & Barthelmebs, L. (2019). Effects of herbicide on non-target microorganisms: Towards a new class of biomarkers? *Science of the Total Environment, 684*, 314–325.

Wanguyun, A. P., & Geraldi, A. (2019). Understanding pesticide degrading-microbe community using molecular approaches. *Pollution Research, 38(August Supplement Issue),* 118–122.

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