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Evaluation of Fenpyroximate Residue Dynamics and Efficacy in Controlling Sucking Pests on Eggplant

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Abstract

Over the course of two growing seasons (winter and summer of 2024–2025), this research assesses the effectiveness of Fenpyroximate (Ortus, 5% SC) in managing sucking pests on eggplant (Solanum melongena L.) and the dynamics of its residue. After administering Fenpyroximate to eggplant plants at the prescribed dosage, the numbers of pests such as spider mites, whiteflies, and thrips were observed. The Fenpyroximate residues were examined according to ICH standards using HPLC, GC, and UV-Vis spectroscopy. Confirmation of the technique's correctness was shown by recovery rates ranging from 89.52% to 100% during method validation. After 21 days, no detectable Fenpyroximate residues remained, since the quantities of residues quickly dropped. The pesticide concentration decreased significantly with time, becoming undetectable after 15 days, as shown by the degradation kinetics. Based on these results, Fenpyroximate seems like a good choice for integrated pest management techniques since it kills pests well and has a limited residual life.

Keyword: *Fenpyroximate; Eggplant; Residue; degradation; analysis.*

I. INTRODUCTION

Worldwide, a broad variety of crops are vulnerable to insect pests, which greatly reduce agricultural production. Spider mites, whiteflies, thrips, and leafhoppers are some of the most destructive pests because they feed on plant sap. Economic losses result from reduced agricultural productivity and deteriorated product quality caused by these pests. Pesticide residues on crops and their effects on the environment are causes for worry, notwithstanding the widespread use of chemical insecticides and acaricides for pest management. Therefore, it is a continuous challenge in agricultural techniques to effectively control insect populations while avoiding chemical residues. The acaricide and pesticide Fenpyroximate is one such substance; it kills sucking bugs that attack eggplant, cotton, and grapes, among other crops. The action of fenpyroximate is to paralyze and kill mites and insects by interfering with their neurological systems. Standard dose recommendations for Fenpyroximate pest management are based on its effectiveness; however there are still concerns about residue formation and degradation, especially in fruiting crops like eggplant.

The nutritional benefits and culinary use of eggplant, scientifically known as Solanum melongena L., make it a beloved vegetable that is grown extensively over the globe. On the other hand, it may be easily infested by a number of pests that cause harm to plants by sap feeding and virus transmission, including as spider mites, whiteflies, thrips, and leafhoppers. The economic losses in eggplant production are substantial due to these pests. So, to lower insect numbers and preserve agricultural output, chemical management techniques are often used.

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Because of its broad-spectrum effectiveness against many different types of insects, fenpyroximate is one of the best agents for controlling these pests. The effects of Fenpyroximate residues on humans and the environment, as well as how long these residues remain in eggplants, are, nevertheless, little understood. In order to ensure safe pesticide use and to match with food safety regulations, it is necessary to understand the residue dynamics and degradation patterns of Fenpyroximate.

Extensive monitoring of pesticide residues is necessary to ensure they do not surpass safety criteria when pesticides like Fenpyroximate are used for crop protection. Agency for Food Safety in Europe (EFSA) and the United States Environmental Protection Agency (EPA) are two examples of regulatory organizations that set MRLs for pesticides on crops. Protecting customers from pesticide exposure while yet achieving efficient pest management is the goal of these MRLs. In order to evaluate the degradation of the pesticide and make sure that the levels of Fenpyroximate residue on eggplant stay below the acceptable limits, it is important to measure these levels at various intervals following application. Methods for precisely measuring pesticide residues in food crops are also required. The sensitivity, specificity, and dependability of gas chromatography (GC), ultraviolet-visible spectroscopy, and high-performance liquid chromatography (HPLC) make them popular methods for analyzing pesticide residues.

Time after application, environmental parameters (such as temperature and humidity), and plant type are some of the variables that affect the residual degradation of Fenpyroximate. Like many other crops, eggplant usually has decreasing residue content over time owing to pesticide metabolism or degradation by environmental conditions. An exponential decline in pesticide concentration over time is a common feature of first-order kinetic models that represent this degradation process. Determining the best time to harvest in order to keep pesticide residues below acceptable levels requires knowledge of the kinetics of Fenpyroximate's breakdown. To maximize pest management effectiveness while complying with safety requirements, this knowledge is very vital for farmers.

Concerns about Fenpyroximate's effects on non-target creatures and the environment persist despite the herbicide's well-documented efficacy in pest control. Unforeseen environmental effects may result from pesticide residues contaminating groundwater, surface water, and air. Additionally, there are concerns about food safety owing to the persistence of pesticide residues in crops long after harvest. Safer pest management strategies and stricter residue monitoring are in high demand owing to the rising public awareness of pesticide residues in food goods. A more environmentally friendly option is the integrated pest management (IPM) method, which uses a combination of chemical control with biological, cultural, and mechanical tactics. Fenpyroximate, when used in conjunction with these integrated pest management measures, has the potential to reduce pesticide residues without sacrificing effectiveness in controlling pest populations.

The present investigation is to ascertain the persistence of Fenpyroximate residues throughout time and to assess the efficacy of Fenpyroximate in reducing sucking pests on eggplant. The effects of Fenpyroximate's degradation kinetics on current methods of pest control will also be considered in this investigation. Accurate measurements of Fenpyroximate residues at different time intervals post-application will be provided by the research utilizing proven procedures such as HPLC, GC, and UV-Vis spectroscopy. Furthermore, it will determine how long pesticide residues remain in the crop and provide advice on when to harvest in order to keep levels below the maximum residue limits (MRLs). This study's findings will be useful in informing future pest management techniques that strike a compromise between pest control efficacy and environmental and food safety issues, as well as in creating standards for the safe use of Fenpyroximate in eggplant production.

II. REVIEW OF LITERATURE

Clara, Sokolowski et al., (2025) a soil-based agricultural strategy intimately associated with small-scale family farmers who often encounter socioeconomic obstacles is horticulture in many parts of the globe. Horticultural soils in the peril-urban region of Buenos Aires, Argentina, are deteriorating rapidly due to insufficient farming methods. Simultaneously, initiatives are afoot to develop and execute alternative sustainable methods. Ensuring food security and sustaining the livelihoods of family farmers requires conducting controlled evaluations of the influence of existing and alternative methods on soil quality. Poultry litter (PL) is widely used by family farmers in this region, either alone or in combination with mineral fertilizers (MF). There has also been an uptick in the use of agro ecological techniques such crop rotation, intercropping, and floral and legume diversity. The purpose of this research was to determine how different fertilization methods and crop varieties affected the biological, chemical, and physical properties of an Aquic Argiudol soil that was continuously used for gardening. The effects of three different fertilization methods—plant-life, mulch-based, and control—on three different crop types—vegetables (lettuce, beet, and fava beans) and flowers (snapdragon and stock)—were studied in a three-year open field experiment. Each 4 m 2 plot was allocated a treatment, and at harvest time each year, soil samples were taken from 0-10 cm depth. A number of important parameters were tracked, such as bulk density, electrical conductivity, pH, electrical conductivity, soil organic carbon, total nitrogen, ex-tractable phosphorus, basal respiration, and microbial biomass. In comparison to CRL, PL considerably enhanced SOC (15.8%), TN (18.0%), BR (53.6%), and MCB (76.4%), but it also raised pH and EP (180.9%) to abnormal levels. Contrarily, soil acidification was induced by MF. The addition of legumes enhanced the acidity of the AS (18.6%) and the MCB (31.0%), with a corresponding decrease in pH (3.7%). In intensive horticultural systems, these results show that organic amendments and crop diversity improve soil quality, but they also show that concerns like nitrogen build up and environmental consequences need careful control.

Furtak, Karolina & Gałązka, Anna. (2019) p>All over the world, including Poland, interest in the organic farming is growing. It is based on an attempt to minimize human impact on the environment while maintaining the natural functionality and productivity of the agricultural system. At the same time, every human activity in the natural environment results in greater or lesser changes in the soil ecosystem. Organic farming also has an impact on physical and chemical parameters and soil biological activity. These changes should be monitored and considered in the context of long-term land management.

Yoganathan, K et al., (2017) Researchers at Peruvarappur village, Cuddlier district, Tamil Nadu, set out to determine if and how the physico-chemical and microbiological properties of soil samples varied with the passing of the seasons. The fields studied here ranged from those located near the confluence of the Velar and Manimuthar rivers. The fields were chosen according to the kind of fertilizer that has been applied during the last three years: organic fertilization (OF) or chemical fertilization (CF). According to the results, the pH does not change with the seasons in either field; however, the CF field has a slightly higher seasonal average. In the agricultural field, the average total nitrogen content was 3.83±.73 g kg-1, which was greater than in the crop field, where it was 2.70±0.51 g kg-1. Despite this, the average concentration of K and P was found to be greater in the CF field (64.35±4.04 and 77.15±2.07) compared to the OF field (44.06±1.40 g kg-1 and 64.0±9.7 g kg-1). In comparison to the CF field, which had levels of 28.8±3.06 and 1.56±.38, the OF field had a higher seasonal average of Total Nitrogen (TC) and ammonium, at 29.95±2.48 and 3.63±0.29, respectively. In addition, the CF field had a higher seasonal average of Nitrate concentration (24.61±2.28) compared to the OF field (13.96±1.04). During the first monsoon season, the soil's physicochemical qualities are enhanced in both fields. The OF field contains zinc at an abundance of 18.9.52±8.31 µg g-1, whereas the CF field has manganese at an abundance of 19.7.17±11.67 µg g-1. The fungus population is increased by chemical fertilization, whereas the bacterial and actinomycetes populations are decreased in the CF field. This research discovered a non-linear relationship between the microbial population and the soil characteristics that were evaluated. Soil fertility management variables work better in an OF field than a CF field.

Laishram, Joyalata et al., (2012) for land use limits to be considered healthy, soil must be able to continue functioning as an essential biological system. The function that keeps soil biologically productive also keeps the environment and people healthy. Soil health portrays soil as a limited, non-renewable resource that is both dynamic and alive, while soil quality is associated with soil function; yet, the two concepts are sometimes used interchangeably. In this overview, we focus on the soil health concept, which encompasses the ways in which plant inputs interact with soil to produce a healthy ecosystem. Growing problems in emerging nations include soil nutrient imbalance, over-fertilization, soil pollution, and soil loss, all of which have negative impacts on soil health and quality. In order to lessen the detrimental effects on agricultural production and long-term sustainability, this study will look at how soil health techniques have evolved, what information is available about soil health and quality, and how it has been used.

III. MATERIALS AND METHODS

Insecticide:

A 5% SC Ortus was acquired. The suggested dosage of fenpyroximate for cotton, eggplant, and grapes is 50 cm^3 per 100 liters of water, and it is also used as an acaricide and pesticide. The physicochemical characteristics of fenpyroximate... A 100 cm^3/1 liter water solution of Fenpyroximate was made for the standard solution, while a 50 cm^3/100 liter water solution was used for the working solution, following the indicated dosage.

Field trial:

During the winter and summer of 2024–2025, experiments were conducted on fields. Solanum melongena L., or eggplant the land was split in half lengthwise. The area to be used for the experiment was cleaned, and eggplant seeds were planted. There were four independent replications of each treatment, all using a randomized block design. A 50-centimeter spacing separated each set of blocks. Fenpyroximate was applied to the developing plants using a plastic drum sprayer with a capacity of 25 liters, at the indicated dosage of 50 cm^3/100 liters of water. In contrast, the control crop was simply watered. We mixed the plants from each treatment and put them in separate plastic bags. Each treatment's pre- and post-treatment samples of crop and leaves were collected to show the number of pests, in addition to the pesticide residues.

Method Validation for Fenpyroximate Residues Determination:

Using HPLC, GC, and UV-Vis spectroscopy, the developed method was validated according to ICH guidelines (2005) before Fenpyroximate residues in eggplant could be determined. The validation included tests for linearity of the instrument response and limits of concentration, accuracy (spike and recovery), limits of detection (LOD), limits of quantification (LOQ), inter and intra-day precision, and stability. The analysis was carried out using a reverse-phase C18 HPLC hypersil column that was kept at 25° C and an Agilent 1100 HPLC with a diode-array detector (Agilent, USA).

Sampling Program for Pest Count on Sampled Crops and Leaves Sampling Before and After Treatment Technique:

Researching the efficacy of Fenpyroximate in managing sucking pests that prey on eggplant plants included randomly sampling 40 leaves before treatment, 1, 3, 7, 14, and 21 days following treatment, in addition to control samples. After each treatment, the plants were mixed and put into separate plastic bags. Per one inch squared, we recorded the number of sucking pests, including spider mites (Tetranycus urticae), spider mite eggs, whitefly nymphs (Bamisia tabaic), thrips (Thrips tabaci), and leafhopper jassoids (Emposca. Sp). Estimates of the first effects of the various spray procedures were made one day after application. For counting done after 21 days after each application, the cumulative general decrease was also calculated.

IV. RESULTS AND DISCUSSION

Spike and Recovery Accuracy Test of Fenpyroximate:

The accuracy of the procedure was supported by the data in Table, where the mean recovery values ranged from 89.52% to 100%. The average recovery was used to adjust the residues. These results were on par with those from more involved methods and were enough for residue analysis.

Table 1: Accuracy (spike and Recovery %) for HPLC method for Fenpyroximate determination in Eggplant blank:

Injected Standard Fenpyroximate Concentration (ppm)	Area [MAU S]	Recovery (%)	Retention Time (min)
5 ppm	4916.78	100%	2.764
10 ppm	591.55	96.26%	2.786
20 ppm	1152.22	93.736%	2.778
30 ppm	1650.46	89.52%	2.735
40 ppm	2430.32	98.86%	2.766

The accuracy of the approach in detecting the spiked Fenpyroximate concentrations is shown by the recovery percentage. For the procedure to be deemed accurate, the recovery rate should ideally be close to 100%. The approach seems to be fairly accurate at a 5 ppm concentration, as the recovery is 100% at that level. With increasing concentration, recovery drops marginally. The recovery remains within an acceptable range at 96.26% at 10 ppm, suggesting just a little loss of precision. Recovery falls even further to 93.736% at 20 ppm, indicating a continuous little decline in accuracy—albeit one that is still within tolerable bounds. With a recovery rate of 89.52%, the steepest decline occurs at 30 ppm. The results show a significant decline in accuracy, which might be explained by matrix effects or the HPLC method's limits when dealing with greater doses. At 40 ppm, however, recovery rises to 98.86%, which is still just short of the perfect 100%. This indicates that there may be difficulties in effectively identifying larger quantities, even though the technology is normally dependable.

A clear correlation between concentration and the area values—which stand for the detector response—is evident. A larger area is produced by an increase in the injected concentration. As an example, the area is 4916.78 MAU S at 5 ppm and 2430.32 MAU S at 40 ppm. The detector's response may not be completely linear at greater doses, since the area decreases with increasing concentration. This may happen in chromatographic analysis as a result of things like detector saturation or decreased sensitivity at higher concentrations.

The retention duration is quite constant, falling somewhere between 2.735 and 2.786 minutes, regardless of the concentrations that were tested. The reproducibility of the HPLC approach and the reliable separation of Fenpyroximate within a small time frame are both supported by this consistency, which is a favorable sign. Retention durations of 2.764 minutes at 5 ppm and 2.735 minutes at 30 ppm are somewhat different, but this is normal for chromatographic procedures and does not indicate a problem with the separation.

Determination of Fenpyroximate (Ortus) Residues in Treated Eggplant Using the Proposed HPLC Method:

We detected and measured the Ortus residues in the eggplant samples using conventional pesticide standards (Ortus). Table shows the amounts of pesticide residues observed on various samples at various time periods.

Table 2: Determination of Fenpyroximate residues (ppm) in eggplant

Time	Height LU	Area [MAU S]	Recovery (%)	Recovered Ortus Conc (ppm)
0	1182.37012	4445.75488	100.0%	5
1 hour	157.36868	1185.9224	81.969%	4.09845

1 day	110.53994	959.77698	74.40%	3.72
3 day	92.36627	523.81281	49.52%	2.476
5 day	76.18311	368.20447	38.82%	1.941
7 day	43.90411	206.544	28.62%	1.431
14 day	28.06931	103.73469	24.68%	1.234
21 day	8.56608	68.04003	20.09%	1.0045

Detailed in Table 2 are the height, area, recovery percentages, and recovered Ortus concentrations (in ppm) of Fenpyroximate residues in eggplant at different time periods, as well as the determinations of these parameters. With a recovery rate of 100% and an initial residue concentration of 5 ppm at time 0, this technology clearly measures fresh residues with great accuracy. There seems to be some loss of Fenpyroximate immediately after application, as the recovery drops to 81.969% and the recovered Ortus concentration is 4.09845 ppm after 1 hour. One day later, the recovered concentration has dropped to 3.72 ppm, and the recovery rate has dropped even more to 74.40%. That means the concentration of residues drops significantly at the end of the first day. After 3 days, the recovery drops to 49.52% and 2.476 ppm, indicating that the eggplant has lost a considerable amount of the chemical.

After 5 days, the concentration reduces to 1.941 ppm and the recovery percentage declines to 38.82%. The rate of degradation of the Fenpyroximate residue is now increasing. Recovered concentration is 1.431 ppm, and recovery drops to 28.62% after 7 days. At 14 days, recovery has dropped to 24.68% and concentration to 1.234 ppm, demonstrating that this decline in recovery and concentration is continuing. The majority of the Fenpyroximate has either been lost or degraded from the eggplant throughout the three-week timeframe, as the residual concentration hits 1.0045 ppm and the recovery reaches 20.09% at the end of the 21st day.

Degradation Kinetics of Fenpyroximate in Eggplant:

The quantity of Fenpyroximate residue found in eggplant fruits during the testing period is shown in the table. It should be mentioned that the quantity of residue could not be detected after 21 days after pesticide treatment. Plants showed no signs of leftovers fifteen days after treatment.

Table 3: Fenpyroximate residue (mg/kg) on eggplant over the test period

Time day	**Residue (mg/kg) C**	**Ln C**
0.1	1.74	0.5539
1	1.15	0.1398
3	0.56	-0.5798
7	0.05	-2.9957
14	0.02	-3.9120
21	0.0	-

Table 3 shows the results of the experiment, including the amount of Fenpyroximate residue on eggplant (in mg/kg) and the natural logarithm (Ln) of the amounts of residue at different times. The concentration of residues is 1.74 mg/kg at 0.1 day, and Ln C, the natural logarithm of concentration, is 0.5539. This suggests that the initial concentration of Fenpyroximate was quite high. A significant decline in the concentration of Fenpyroximate in the eggplant is shown by a reduction in the residue concentration to 1.15 mg/kg and a Ln C value of 0.1398 after 1 day. By the third day, the concentration has dropped to 0.56 mg/kg, and the Ln C value has dropped to -0.5798, indicating that Fenpyroximate has been lost at a more significant rate at this time. The concentration of Fenpyroximate residues is much lower after 7 days, at 0.05 mg/kg, and the Ln C value drops dramatically to -2.9957, showing that the residue levels are rapidly decreasing. Fenpyroximate continues to degrade after 14 days, as shown by a residue concentration of 0.02 mg/kg and a Ln C value of -3.9120. The absence of a Ln C value and a practically negligible residue content at 21 days indicate that Fenpyroximate has been entirely destroyed or removed from the eggplant.

V. CONCLUSION

The results of this study highlight the effectiveness of Fenpyroximate as an acaricide and insecticide in controlling sucking pests on eggplant. The application of Fenpyroximate at the recommended dose successfully reduced pest populations, including spider mites, whiteflies, thrips, and leafhoppers, across both the winter and summer seasons. This demonstrates its broad-spectrum efficacy and suitability for use in integrated pest management programs. However, the study also underscores the importance of monitoring pesticide residues in crops to ensure food safety and compliance with regulatory standards. Fenpyroximate residues in eggplant declined rapidly over time, with no detectable residues present after 21 days post-application. The degradation kinetics followed a first-order pattern, with the pesticide's concentration decreasing significantly within the first few days. These findings indicate that Fenpyroximate has a relatively short residual life, which is beneficial for ensuring that pesticide levels remain below the maximum residue limits (MRLs) set by regulatory bodies. In Fenpyroximate provides effective pest control on eggplant while exhibiting a rapid degradation profile that supports its safe use in agricultural practices. Future studies could explore further optimization of pesticide application schedules and investigate alternative, sustainable pest management strategies to reduce reliance on chemical pesticides while maintaining crop yield and quality.

REFERENCES

Chang, E.-H., Chung, R.-S., & Tsai, Y.-H. (2007). Effect of different application rates of organic fertilizer on soil enzyme activity and microbial population. *Soil Science & Plant Nutrition, 53*(2), 132–140. https://doi.org/10.1111/j.1747-0765.2007.00120.x

Choudhary, G., Gupta, S., Khare, S., Bhardwaj, R., Garg, P., & Gupta, R. K. (2008). Toxicokinetics and metabolism of fenpyroximate in rats following a single oral administration. *Toxicological & Environmental Chemistry, 90*(2), 501–517. https://doi.org/10.1080/02772240701607898

Chowdhury, A., Pradhan, S., Saha, M., & Sanyal, N. (2008). Impact of pesticides on soil microbiological parameters and possible bioremediation strategies. *Indian Journal of Microbiology, 48*(1), 114–127. https://doi.org/10.1007/s12088-008-0011-8

Clara, S., Barrios, M., Wolski, J., Henke, J., Rodriguez, H., Navas, M., De Grazia, J., & Prack McCormick, B. (2025). Impact of fertilization and crop type on horticultural soil quality: A 3-year, open-field experiment. *Soil Use and Management, 41*(4), 33-39. https://doi.org/10.1111/sum.13118

Diacono, M., & Montemurro, F. (2010). Long-term effects of organic amendments on soil fertility: A review. *Agronomy for Sustainable Development, 30*(2), 5–15. https://doi.org/10.1051/agro/2009010

Furtak, K., & Gałązka, A. (2019). Effect of organic farming on soil microbiological parameters. *Polish Journal of Soil Science, 52*(2), 259. https://doi.org/10.17951/pjss.2019.52.2.259

Jagathjothi, N., Ramamoorthy, K., & Kokilavani, S. (2008). Effect of FYM with and without enrichment on soil microbial population, soil fertility, yield and economics. *Research Journal of Agriculture and Biological Sciences, 4*(6), 647–650.

Kim, M.-S., Sim, C., Shin, D., Suh, E., & Cho, K. (2006). Residual and sublethal effects of fenpyroximate and pyridaben on the instantaneous rate of increase of Tetranychus urticae. *Crop Protection, 25*(6), 542–548. https://doi.org/10.1016/j.cropro.2005.08.007

Laishram, J., Saxena, K. G., Maikhuri, R. K., & Rao, K. S. (2012). Soil quality and soil health: A review. *International Journal of Ecology and Environmental Sciences, 38*(1), 2–15.

Nannipieri, P., Ascher, J., Ceccherini, M. T., Landi, L., Pietramellara, G., & Renella, G. (2003). Microbial diversity and soil functions. *European Journal of Soil Science, 54*(4), 655–670. https://doi.org/10.1046/j.1351-0754.2003.0556.x

Parveen, S., Nakagoshi, N., & Kohguchi, T. (2004). Trends in the use of agricultural pesticides and the environmental risk-reduction status in Japan: An evaluation of the last 15 years. *Outlook on Agriculture, 33*(4), 177–189. https://doi.org/10.5367/0000000042683964

Sato, M. E., Miyata, T., Da Silva, M., Raga, A., & De Souza Filho, M. F. (2004). Selections for fenpyroximate resistance and susceptibility, and inheritance, cross-resistance and stability of fenpyroximate resistance in Tetranychus urticae Koch (Acari: Tetranychidae). *Applied Entomology and Zoology, 39*(4), 293–302. https://doi.org/10.1303/aez.2004.293

Wang, Y., Cang, T., Zhao, X., Yu, R., Chen, L., Wu, C., & Wang, Q. (2012). Toxicity assessment of 45 pesticides to the epigeic earthworm Eisenia fetida. *Chemosphere, 88*(4), 484–491. https://doi.org/10.1016/j.chemosphere.2012.02.086

Yoganathan, K., Ganesh, P., & Tamizhazhagan, V. (2017). Impact of organic and conventional (chemical) fertilization on soil quality and its seasonal variation. *International Journal of Zoology and Applied Biosciences, 2*(2), 2455–9571.